CEREAL CHEMISTRY

Formerly the Journal of the American Association of Cereal Chemists

Vol. I July, 1924 No. 4

LIPOIDS, A FACTOR INFLUENCING GLUTEN QUALITY[1]

By Earl B. Working

Department of Milling Industry, Kansas State Agricultural College, Manhattan, Kansas

(Received for publication June 2, 1924)

General Discussion

In this paper the term "lipoids" is used to denote the substituted fats containing nitrogen or nitrogen and phosphorus, and the term "phosphatides" includes only the phosphorus-containing lipoids.

The original theory of a plasmatic membrane or surface layer of lipoids, as proposed by Quincke[2] and by Overton,[3] has received a great deal of adverse criticism. Many writers have assumed that lipoids are immiscible with water and that therefore a lipoidal surface layer would prevent the entrance of water into the cell. However, the lipoids absorb large quantities of water and form either emulsions or true solutions with it, thus readily permitting the entrance of both water-soluble and fat soluble materials into the cell. The most tenable theory of lipoid distribution in the plant cell, as developed by Czapek,[4] Hansteen-Cranner,[5] MacDougal,[6] and others, seems to be that the lipoids form a peripheral layer, with a meshwork extending into both the protoplasm and the cell wall. This is in accord with the great reduc-

[1] Contribution No. 24 from Dept. of Milling Industry, Kansas Agricultural Experiment Station.

A report of this investigation was given before the chemical section at the meeting of the American Association for the Advancement of Science, December, 1923, at Cincinnati, Ohio.

[2] Quincke, G. Ann. d. Physik u. Chemie, N. F., Vol. 35, p. 580 (1888).

[3] Overton, E. Osmotische Eigenschaften, Vierteljahrsschr. Naturforsch. Ges. Zurich, Vol. 40, p. 1 (1895).

[4] Czapek, F. Zum Nachweise von Lipoiden in Pflanzenzellen, Ber. d. Deutsch. Bot. Gesell., Vol. 37, pp. 207-286 (1919).

[5] Hansteen-Cranner, B. Beiträge zur Chemie und Physiologie der Zellwand und der plasmatischen Grenzschichten, Ber. d. Deutsch. Bot. Gesell., Vol. 37, pp. 380-391 (1919).

The biochemistry and physiology of the surface layer of living cells, Medd. Norges Landbruckhois, Vol. 2 (1922).

[6] MacDougal, D. T. The probable action of lipoids in growth. Proc. Amer. Phil. Soc., Vol. 61, pp. 33-52 (1922).

tion of surface tension caused by the lipoids. Palladin's observation of the dependence of respiration upon the lipoids is also of interest here, particularly on account of their relative abundance in those cells in which metabolism is more active.[7] The whole theory agrees well with the distribution of the lipoids in the wheat kernel. The highest percentage is located in the germ, considerable amounts are found in the inner bran coats, and smaller quantities are distributed throughout the endosperm.

Osborne[8] reported the presence of a phosphatide, which he called lecithin, in the gluten washed from wheat flour. This was confirmed in this laboratory, and it was found, further, that more phosphatide is present in the gluten from the lower grades of flour. If an interwoven meshwork be accepted as the picture of protein structure, it will almost necessarily follow, on account of their reduction of surface tension, that the phosphatides will be found distributed at the interfaces of this meshwork. When a rope is oiled it loses its strength—its tenacity—because the interwoven strands of manila are lubricated. It would seem that phosphatides should have a similar effect on wheat gluten.

On account of these theoretical considerations it seemed that a study of lipoids in relation to gluten quality should prove valuable, and altho the work is merely started, the results seem to justify this preliminary report.

Methods and Materials

Gluten quality was measured in three ways: by the feel of the hand-washed gluten; by viscosity as measured by the MacMichael viscosimeter; and by baking tests. A lecithin-like phosphatide (or, probably, a mixture of phosphatides) was prepared from freshly-milled graham flour and purified by the method of MacLean.[9] Commercial lecithin from eggs was used for comparison.

Experimental Work

Experiments with Hand-washed Gluten

Crude gluten prepared from low-grade flour, using distilled water, was very soft and weak. Upon long-continued washing it gradually became more tenacious, finally becoming practically equivalent to that washed from patent flour. After most of the starch had been removed, small portions of water were used for the washing and this was saved

[7] Palladin, W. and E. Stanewitsch, Die Abhängigkeit der Pflanzen=atmung von den Lipoiden. Biochem. Zeit., Vol. 26, pp. 351-369 (1910).

[8] Osborne, T. B. The proteins of the wheat kernel. Carnegie Inst. of Wash. Pub. 84, p. 108 (1907).

[9] MacLean, Hugh. Lecithin and allied substances. pp. 78-81, London (1918).

and evaporated to dryness under high vacuum. The residue was extracted with absolute alcohol and the solution evaporated under vacuum. The ether-soluble portion of this residue gave a strong test for phosphorus.

The phosphatide content of crude gluten from patent flour was experimentally increased by dissolving phosphatide in the water used for mixing the dough. Wheat phosphatide, 0.0625 grams or 0.25 per cent added in this manner to patent flour made the gluten very much softer than normal gluten, and 0.5 per cent made it fully as soft as gluten from low-grade flour. When 3 per cent of phosphatide was added, the crude gluten could not be recovered on account of its lack of tenacity. Egg lecithin seemed to have a slightly greater effect than wheat phosphatide. Phosphatide added to patent flour appeared to wash out somewhat more readily than that normally present in low-grade flour.

Other colloids, such as pentosans and the soaps, were also found to have a marked effect upon the crude gluten. From 25 grams of patent flour washed with distilled water, 2.72 grams of dry gluten was obtained, but when 0.5 gram of gum acacia was added to the dough, 3.62 grams of dry gluten was obtained, and while the percentage content of nitrogen in this gluten was comparatively low, the total content was 0.432 gram nitrogen as against 0.394 gram in the gluten washed from flour with no gum acacia added. When soap was added to the water used in mixing the dough, the first effect was very similar to that caused by the addition of phosphatide; that is, the gluten was very soft and lacked tenacity. However, upon prolonged washing, instead of becoming tenacious the gluten became brittle and harsh. It is possible that this may be due in part to the washing out by the soap of the lipoid normally present and so strongly adsorbed as to prevent its being removed by water alone. There are, of course, several other possibilities, such as the adsorption of the sodium ion, or the washing out of some gliadin.

Viscosity Tests

Much work on gluten quality has been done by Gortner and Sharp[10] by means of the MacMichael viscosimeter. Several large mills report that this instrument offers one of the best means yet developed for checking the uniformity of their flour.

The method used for the viscosity determinations was as follows: 20 grams, dry weight, of flour was suspended in 100 cc. of water and

[10] Gortner, R. A. and Sharp, P. F. The physico-chemical properties of strong and weak flours. Jour. Phys. Chem., Vol. 27, pp. 481, 567, 674, 771 (1923).

allowed to stand for an hour with frequent shaking. Two cc. of U. S. P. lactic acid was then added, the mixture shaken and poured into the viscosimeter cup, and the deflection in degrees MacMichael read, using a No. 30 wire and the disc bob, with a speed of exactly 12 revolutions per minute. Table I shows the effect of the addition of wheat phosphatide, of egg lecithin, of soap, and of wheat oil upon the viscosity of flour suspensions prepared in this way. When the wheat oil was first added to a suspension of flour having an H-ion concentration of pH 6.5, it reduced the viscosity so much as to be readily apparent upon shaking the suspensions, but after adding the lactic acid there was no appreciable difference.

TABLE I
EFFECT OF LIPOIDS, SOAP, AND FAT ON THE VISCOSITY OF FLOUR SUSPENSIONS

	Amount added						
	0.0%	0.25%		0.5%		1.0%	
	Degrees	Degrees	Decrease	Degrees	Decrease	Degrees	Decrease
	M	M	%	M	%	M	%
Wheat phosphatide	340	...	...	228	33	204	40
Lecithin	340	303	11	282	17	245	28
Soap	340	309	9	286	16	218	36
Wheat oil	340	...	...	...	...	331	2.6

On account of the known action of salts in reducing the hydration of gluten by acids, Gortner and Sharp[11] extracted flour with distilled water to remove the water-soluble ash salts, and found that this treatment brought the viscosity of a clear flour close to that of a patent milled from the same wheat. It seemed that the removal of lipoids and other water soluble materials not investigated by Gortner and Sharp might have some part in producing this effect, so the water extract of 40 grams of flour was evaporated under vacuum and the residue extracted with absolute alcohol. The alcohol was evaporated under vacuum, and the ether extract of this residue gave 1.4 mg. of P_2O_5, which would correspond to perhaps 0.1 per cent of phosphatide.[12] On account of the instability of the phosphatides, this result could scarcely be considered even approximately quantitative, and yet 0.1 per cent of phosphatide had a marked effect on the viscosity of the suspension of a flour that had been extracted with water. Moreover, considerable quantities of leucosin and gliadin are removed by the water extraction, and possibly some pentosan. To simulate the effects of these materials, wheat phosphatide, albumin, and gum acacia were added to extracted flour before measuring the viscosity. The results are given in Table II.

[11] Gortner, R. A. and Sharp, P. F. Jour. Phys. Chem., Vol. 27, p. 674 (1923).

[12] Winterstein, E. und K. Smolenski. Beiträge zur Kenntnis der aus Cerealien darstellbaren Phosphatide. Zeit. Physiol. Chem., Vol. 58, p. 518 (1909).

TABLE II

EFFECT OF PHOSPHATIDE, EGG ALBUMIN, AND GUM ACACIA ON VISCOSITY OF SUSPENSIONS OF FLOUR EXTRACTED WITH DISTILLED WATER

	Degrees M	Per cent reduction
Extracted flour	660	..
Extracted flour + 0.1% wheat phosphatide	587	11
Extracted flour + 0.5% egg albumin	615	7
Extracted flour + 0.5% gum acacia	633	4

As a further test of the effect of the removal of ash salts on the viscosity of flour suspensions, a series of flours, patent, clear, and low grade, was dialyzed for 20 hours, and a check series merely allowed to digest in water for this time, and then extracted with water by the method of Gortner and Sharp. The viscosities of the suspensions thus obtained were determined. Toluol was used to inhibit bacterial action. Collodion bags hardened with alcohol were used for the dialysis. The results obtained are given in Table III.

TABLE III

EFFECT ON VISCOSITY OF FLOUR SUSPENSIONS CAUSED BY THE DIGESTION, THE DIALYSIS, AND THE EXTRACTION OF THE FLOUR WITH DISTILLED WATER

	Usual method, degrees	Extracted with H_2O, degrees	Digested 20 hours, degrees	Dialyzed 20 hours		Digested 20 hours then extracted	
				Degrees	%	Degrees	%
Grade of flour	M	M	M	M	ash	M	ash
Patent	340	657	231	297	0.14	402	0.12
Clear	170	653	103	152	0.18	367	0.18
Low grade	232	821	147	174	0.20	411	0.17

The dialyzed samples show a decided increase in viscosity over those merely digested in water. This is presumably due to the removal of ash salts, but the very much greater increase in viscosity shown by the samples which were digested and then extracted can scarcely be due to the slightly lower ash obtained by this treatment, but must rather be due to the removal of other water-soluble materials. As has been shown, a very small amount of phosphatide will make a decided difference in viscosity, and the water-soluble protein and even the pentosan may be of importance.

In drawing conclusions from viscosities measured by the method described, it should be kept in mind that the viscosity is measured at about pH 3, and therefore does not necessarily parallel the viscosity at pH 5, which is approximately the H-ion concentration of bread dough ready for the oven. Also, it should be noted that a reduction in the apparent viscosity may be caused in three ways; by an increase in the hydration of the gluten, as by strong acids; by a decrease in the

hydration of the gluten, as by salts; and by a decrease in cohesiveness, as by the introduction of surface films of phosphatide or soap.

Baking Tests

The baking tests were made with a patent flour milled from hard red winter wheat. The baking method was that adopted as standard in the flour testing work of this laboratory. Table IV shows the maximum expansion of the dough, the loaf volume, and the grade assigned to the texture of the crumb for a series with wheat phosphatide and a separate series with egg lecithin. Where the larger quantities of wheat phosphatide and lecithin were used, the weakening of the gluten was very noticeable in the handling of the dough.

TABLE IV

EFFECT ON MAXIMUM EXPANSION OF DOUGH, LOAF VOLUME, AND TEXTURE OF CRUMB, CAUSED BY ADDITION OF INCREASING AMOUNTS OF WHEAT PHOSPHATIDE AND OF EGG LECITHIN

	Max. expansion cc.	Loaf volume cc.	Texture %
Standard flour	2100	2020	95
Standard flour + 0.25% phosphatide	2100	2055	93
Standard flour + 0.5% phosphatide	2200	2020	88
Standard flour + 1.0% phosphatide	2250	1975	80
Standard flour	2100	2030	95
Standard flour + 0.25% lecithin	2150	2035	92
Standard flour + 0.5% lecithin	2200	2005	80
Standard flour + 1.0% lecithin	2250	2005	78

Summary

Prolonged washing of the soft gluten from low-grade flour removed phosphatide and gradually increased the tenacity until the gluten was practically equal to that from patent flour.

Phosphatides added to flour in small quantities injured the gluten quality as measured by the feel of the hand-washed gluten, by viscosity as measured by the MacMichael viscosimeter, and by baking tests.

Removal of ash salts from flour by extraction with distilled water removed a significant amount of phosphatide, as well as proteins and possibly pentosans in an amount sufficient to affect viscosity.

THE CAKE FLOUR LABORATORY

By P. M. Patterson
Igleheart Brothers, Evansville, Indiana

(Read at the Convention, June 11, 1924)

The primary purpose of this paper is to supply to those not well acquainted with this class of work, an outline of the various points of attack in determining the suitability of a flour for cake making as differing from the requirements and methods in ordinary use among cereal chemists, most notably the bread-flour men.

Probably of greatest importance is the physical condition of the flour particles, as other requirements can be cared for through tempering, bleaching, or wheat selection.

For uniform cake texture, the flour particles should be as nearly identical in size as possibie, and the ideal seems to require that each individual starch cell be separated from its neighbor, not a practical possibility, but an ideal. Our experience, through daily examining samples under the microscope, and routine tests, shows us that the closer we approach this condition, and the finer the chunky or massive particles become, the lighter and of more delicate texture the cake,

This effect we have carefully checked many times with varying granulation obtained from sifting a heavy load through No. 18 silk, and a light load through No. 11 silk, and invariably find the same results.

Cake texture does not depend so greatly upon the working of a batter, as does bread texture upon the mixing and kneading of a yeast-raised dough, but with ordinary care in mixing, it does depend upon what we choose to call the rupture point of the CO_2 bubbles, which in turn is greatly affected by granulation. By this we mean the size to which the gas bubbles develop before they rupture, allowing the gas to escape.

Upon this characteristic of a batter depend several features of cake texture, and this itself depends upon not only the physical condition of the flour particles, but upon the nature and amount of what we call by the familiar name gluten.

In the ideal cake the gas cells should expand to about 1/16 of an inch in diameter, at which point the cell walls should rupture slightly, allowing the excess gas to escape; otherwise a very fine baking powder must be used, and in small quantity, or the texture will be coarse; and with many large bubbles bursting at the same time, a fallen cake results.

Granulation and gluten condition have also a very important bearing upon the cake produced, particularly with regard to the nature ot the crumb, whether it be fairly dry and fluffy, indicating that the batter-

emulsion held until the cake was set; or whether, as in the case of a waxy or greasy crumb and a sugary crust, the emulsion has broken down, allowing the sugar to go into solution with the liquid leaving the shortening with its natural absorbent, the starchy particles.

In the ideal butter cake—that is, a cake containing shortening—the transition from the batter-emulsion stage to the nearly dry finished product is very gradual and the batter is easily affected by unfavorable conditions such as are caused by a high acidity effect on the flour, or a gluten of such a nature that it will not combine with the liquid-shortening-sugar emulsion.

Not being equipped with a viscosimeter, and relying upon information gained through the use of pipette-viscosimeters and stop-watch, we are as yet unable to give any reliable information as to this point. However, all the tests we have made indicate strongly that the action of the gluten in the batter can be very safely indicated by the protein-viscosity relationship.

We have not found the addition of lactic acid to batters for viscosity determinations on cake flour to be of benefit, but have used a dilute solution of di-sodium phosphate, and also potassium sodium tartrate, being end products of baking powder reactions, with an aim at approaching the cake batter condition. This work we intend carrying on with a torsion type viscosimeter this coming year.

As a test cake mixture, we use the following:

	Grams
Sugar	175
Shortening (Crisco, Selex, Scoco)	75
Egg albumen	5
Powdered milk	15
Salt	5
Baking powder	10
Flour	225
Water	250 cc.

All dry ingredients are sifted together. The standard can be prepared ahead and 260 grams used instead of making the separate weighings.

Egg albumen, milk, salt, and baking powder can also be blended together, using from 35 to 225 grams of the flour to be tested. The baking powder used is a phosphate mixture as follows:

	Grams
Mono calcium phosphate	150
Sodium pyro phosphate	50

Soda	150
Flour or starch	50

The sodium pyro phosphate is used with the mono-calcium because of its slower activity, which is desirable in a cake; whereas in a biscuit, which bakes in about 10 minutes, the leavening ingredients must fully react within that short period.

The shortening and sugar mixture can be creamed up in ten or more times the quantities given, kept in a cool place, and used as wanted, taking 250 grams of the mixture.

Egg albumen and milk powder are used because of uniformity in amount, no two fresh eggs weighing alike, and no two milks having the same fat and acidity; also for convenience in handling.

So far as we have been able to determine, the cake-making qualities of a flour, therefore, are governed by the following conditions:

1. Uniformly fine division of the flour particles, freedom from chunks and flakes.

2. The relation of gluten quantity to physical condition, and also physical condition after being acted upon by various solutions representing the end products of baking powder reactions.

3. Inclination of the gluten colloid properly to combine and maintain its relation with the batter emulsion.

BREAD TROUBLES IN THE LIGHT OF HYDROGEN-ION CONCENTRATION

By Rowland J. Clark
Goerz Flour Mills Company, Newton, Kansas

(Read at the Convention, June 11, 1924)

The purpose of this discussion is not to announce some new discovery or to propound a new theory; but to call attention to a simple fact, which if practiced, will prove valuable; and under this fact, to point out the relationship of fundamental ideas which doubtless are quite familiar to every one. Very frequently when bakers and even chemists discuss bread troubles, the conclusion reached is that the flour is "off" and that the flour caused the coarse grain, the pale crust, the uneven break and shred, or the dry crumbly crumb. Little or no attention is paid to the yeast, which is a far more perishable product than flour; to the malt extract, which contains more variable factors than flour, or even to the salt, which in late years has frequently had incorporated in it a chemical which not only prevents caking but also retards fermentation. Frequently discussions of bread ailments bring out many important remedies, but why the remedies were prescribed

often remains unknown. It is not thus intended to champion flour as being the only perfect ingredient used in bread making, but to present a simple fact which, when observed, serves as the keystone in analyzing and placing the blame for the bread trouble.

In 1911 Jessen-Hansen found that a flour baked best when its dough had a hydrogen-ion concentration of approximately pH 5 and said, "for the dough of any wheat flour there exists a determined concentration of hydrogen ions, with which the production of bread from this flour will be most successful." "This optimum concentration corresponds approximately to the exponent of hydrogen ions pH 5. For choice flours this appears to be a little higher. For the ordinary or bad kinds on the contrary it is slightly lower."

Weaver and Goldtrap announced in 1922 that any one of the flours with which they experimented was capable of making a good loaf of bread with large volume, good pile and texture. They said, "It all seems to be a matter of starting with the right absorption and finding the correct fermentation period."

Morrison and Collatz found in their "Studies on the Control of Rope in Bread" that it was very difficult to produce bread of good quality and at the same time obtain the required hydrogen-ion concentration necessary to inhibit rope, namely pH 5. By far the greater number of their best loaves contain a pH 5.2 to pH 5.8.

Bailey and Sherwood have reported that on seven straight doughs run under commercial conditions an average of pH 5.75 was obtained on the resulting bread, and from another series of four doughs an average of pH 5.66 resulted. Judging, therefore, from these authorities, when flour delivers its maximum baking value, there exists a very definite pH in the resulting bread.

This forms the kernel of the present discussion. Bread can be judged young because its pH is too high or it can be judged old because its pH is too low. Just as the main street of a western town may divide the cluster of houses, so there is a dividing line between young and old bread. As this line is approached from either side the bread takes on larger volume, finer grain, and better crumb color. Bread whose pH value falls on this line shows the maximum baking results. As this line is receded from, the volume decreases, the grain grows more open and the color is injured. For bread from some flours, this line seems a broad avenue and a variation of several tenths of a pH from curb to curb seems to make little change in the apparent physical properties of the loaf. For bread from other flours this line is a narrow alley, and a small variation in the pH value throws the loaf distinctly into the outskirts of the town. Much experimental evidence

both in literature and in the writer's experience points to the fact that ideal loaves or loaves containing the maximum baking results may vary from pH 5.50 to pH 5.70. Chemically speaking these are wide limits, but commercially speaking they are very narrow.

There is great need of standardization in the age of bread, first among chemists themselves. It is interesting to know that by recent inquiry among twelve chemists from southwestern Kansas mills, no two laboratories followed exactly the same baking procedure, or obtained the same kind of bread. It was also learned that the consideration of what constituted a good loaf of bread varied as each chemist expressed his opinion. Is not the loaf obtained when the flour produces its maximum baking qualities a good loaf, and a loaf which does not exhibit the maximum volume, fine grain, desirable color, and other good points inferior to what it is possible to make from the same ingredients? Why should a laboratory or bakery have a set fermenting time for all flours? Why give all flours the same absorption? Why place a flour under a rigid set of conditions and if it fails to fit call it poor? Why not suit the conditions to the flour, not the flour to the conditions? These probably seem foolish questions to some; but many chemists as well as bakers are condemning flours and blaming the millers for poor milling when in reality the flour is good.

If one bakes too old or too young loaves, only part of the variables of the flour are determined. This practice might be compared to throwing a ball up in the air through a clump of interfering tree limbs. If the ball catches in the foliage going up, the height to which it would have gone can not be told; or if it catches in dropping down, its height of rise is lost; but if the very highest point of rise can be found then the force behind the ball is known as well as its direction of travel. Just so with a dough, if caught going up on the young side or coming down on the old side its full baking force is never realized. The absorption is perhaps about the only variable thus found. If one secures the right absorption and gives the dough just time enough to reach the pH recommended by Jessen-Hansen, one secures all the variables produced when the flour does its best work. By thus baking each flour to produce its best results, the variable factors such as absorption, volume, fermenting period, proof period, etc., are learned. If a flour mill can, by knowing these factors, produce a flour from which the bread variables are more or less constant (within at least narrow limits) a uniform flour is bound to result. Therefore more accurate mill control will result in ascertaining the variable flour-to-bread factors.

Second, there is need of bread age standardization among bakers.

It has been found that very few bakers produce bread on the young side, in fact their conception of young and old bread seems quite different from the chemists' conception. Their argument is that volume can not be secured by baking any younger, but the writer has shortened the fermenting time of several bakers as much as an hour and been rewarded by twice the oven spring formerly obtained. Now pH in the life of a baker means little or nothing, but by varying the time of two or three doughs and the careful inspection of the resulting bread, the correct fermenting period can easily be found. The success of many bakers has been due to an almost superhuman ability to judge bread age correctly by inspection and regulate their doughs accordingly.

Having considered somewhat the theoretical aspect of young and old bread, of what practical value is the recognition of this bread quality? It is of the utmost practical value because by the application of the information as to whether a loaf is young or old more than half the bread troubles can be rectified.

How can one tell when bread is young or old? There are perhaps two methods which can be used separately or combined. First by its physical appearance, second by a pH determination either electrometrically or colorimetrically. Doubtless the coarse grain, gray white crumb color, sour odor, pale crust, poor oven spring, with worm-eaten appearing bottoms and sides are familiar old-loaf ear-marks to those experienced in bread baking; while the soggy, heavy, thick cell walled, gluten bound appearing, smooth sided, sharp edged loaves are young characteristics well known to every one. Practice in grading bread renders one capable of distinguishing young from old bread, at least between wide limits; and frequently years of experience will enable the detection of a very small pH variation. Bakers naturally can, if interested, become quite proficient in this art.

The second method, that of pH determination, if done electrometrically, is the most accurate; but requires a laboratory, some delicate apparatus and an experienced operator. Altho this is the basic method of distinction between young and old loaves, the technic required renders it suitable only for a laboratory. A method which has been suggested by Cohn, Walback, Henderson, and Cathcart is very simple; and, because of its approximate accuracy, can be used by bakers and chemists alike. This method employs an indicator which is streaked across the freshly cut surface of a loaf and after five minutes the shade of the coloration indicates the pH value. Two-tenths of a pH unit can be easily distinguished in this way. Any indicator whose pH range includes the divisional line between old and young bread is

suitable; but because of the ease of preparation and the abundant supply, para-nitrophenol from Sorensen's selected indicators; ortho-carboxy-benzene-azodi-methyl-aniline (methyl red) and di-bromo-ortho-cresol-sulfon-phthalein (brom cresol purple) from Clark and Lubs' list of indicators, and 2.5 dinitro-phenol from Michaelis' indicators seem the best suited for bread work.

Being thus in a measure prepared to distinguish between young and old bread, the knowledge can be very valuable, especially to a chemist when he is called upon to analyze bread troubles in both laboratory and bakeshop. Regardless of how carefully a flour mill is managed or how accurate the control and how uniform the flour, sooner or later a complaint will arise to settle which will demand the presence of the chemist in the bakeshop. Complaints might be classified under three heads: (1) Those arising under a falling market; (2) those in which the flour is at fault, as musty, over-aged, wormy, over-bleached, etc.; (3) those in which the baker is at fault, as poor ingredients or poor baking technic. By far the most troublesome to the chemist is the complaint on a falling market, because in reality nothing is wrong with the flour except the price; but the baker refuses to be convinced of the flour's quality. The second class of complaints, in which the flour is at fault, can sometimes be detected by inspection and soon adjusted. The third class, in which the baker is at fault, and cases of the second class not readily detected by inspection, are of grave concern to the chemist when he reaches the bakery. What is the trouble in the first place and what is to be done to straighten out the tangle? Some clue to the situation and a systematic method of procedure would be handy instruments.

The inspection of a loaf of bread will tell far more accurately than the baker can describe just what conditions exist. The most important fact is whether the loaf is young or old. A loaf is young or old because of (1) its ingredients, (2) its treatment.

The primary requirements in ingredients for the white bread so common to the home table of today are flour, water, sugar, salt, and yeast. These constituents will produce a very good loaf of bread with good flavor; but because the public demands a very rich flavor, other materials, milk, shortening, yeast foods, and malt extract, are employed.

Flour is the foundation of bread. It is the stiffening material which forms the backbone of the loaf. If too much flour has been used for the amount of water the dough is stiff, fermentation is slowed up, and the bread is young, other factors remaining constant. If too much water has been used for the amount of flour, the dough is slack, fermentation is speeded up, and the bread is old.

Water is essential to give the proper consistency to the bread. Too hard water containing large amounts of calcium and magnesium salts will very materially slow up fermentation, and therefore require a longer time to bring the dough to the proper age. Water of medium hardness stimulates fermentation, causing the yeast to work faster than usual. With extreme hardness the bread is young, with medium hardness the bread is old, if other factors are not regulated.

Sugar can be broken up into carbon dioxide and alcohol by the action of yeast, and this is exactly what happens in the dough. Sugar, then, is needed for fuel for the yeast and for flavor to the bread. Up to a certain point sugar stimulates fermentation, but beyond this point it retards; therefore, it depends upon the quantity used as to whether the bread is young or old if nothing else is changed. Leave sugar out of a dough and it requires a very long time to ferment and the loaf has a pale crust.

Salt is generally thought of as toughening the gluten and adding flavor to the loaf, therefore with an over amount a much longer fermenting time is required for the bread. Likewise, too small an amount retards fermentation and the absence of salt in a dough will make a soggy, flat, bad-tasting loaf. A loaf may therefore be young or old because of the varying amounts of salt used.

It is well known that an excessive amount of yeast in a dough causes a yeasty odor, hurries up fermentation, and may make a dark colored crumb. The bread thus produced is old. Too small an amount causes slow fermentation, or makes a young loaf.

Thus each necessary ingredient has the power of making the loaf young or old, if varied alone, or of counteracting each other if working in opposite directions. Slackness in a dough which causes quick fermentation and an old loaf might be helped by a shortened fermenting period. Stiff doughs could be remedied in part by longer fermentation. Milk, yeast foods, and malt extract, if used in a bread formula, can very easily and quickly throw a dough from the young to the old side. To sum up the main purposes of the various bread ingredients, it can be said that if the treatment of the dough is the same for each loaf, the ingredients alone can make or break a loaf.

As much depends upon the proper handling of a dough as upon the ingredients. As in any fermentation industry, temperature is the most important factor and time next. Any one who has handled dough knows that temperatures above 81°F. promote fast fermentation and the propagation of wild yeasts, and unless compensated for an old loaf will result. If all the ingredients are in the right proportions and the handling of the dough through the machines is correct but the fer-

menting time is too short or too long, a young or an old loaf will result. Very frequently too rough treatment, such as excessive mixing in a high speed mixer, too tight setting of the rounding machine or the molding machine, too long time in the overhead proofer, or too much handling on the bench, will make an old dough out of an otherwise young one. If the pans are too large for the size of the dough scaled high acidity may result through overproofing. The practice of running steam into a proofing box to regulate the humidity is all right if properly watched; but when moisture collects on the bread until the loaf is almost floating in the pan, it is a safe conclusion that the loaf will be high in acidity from overproofing. It is quite common to find among bakeries too small oven capacity. By constant crowding, the oven temperature drops; so unless the proof period and perhaps the fermenting time be shortened, high acidity will again result. Because of lack of oven space a dough may have to stand in the trough longer than it should, thereby making an old loaf. These are only a few instances of points in the process of manufacture at which a loaf may be changed from young to old.

It is doubtless apparent that there are countless points to be watched in making good bread. Many factors work to produce the same effect in the finished loaf, many work against or counteract each other. To look at a loaf and say instantly that one and only one point is the cause of the trouble is not advisable; but the instant an experienced bread judge examines a loaf, a picture of that loaf's life history should come up before his mind. If the loaf is old (as the great majority of bread is) all the possible factors of both ingredients and handling which contribute to make an old dough are grouped together; while if the loaf is young, the factors causing a young dough are reviewed. Having judged the bread age, the source of trouble can be located quicker and remedied easier than if, in a haphazard way of trying this and that, luck is resorted to in finding the defect. Enough experiment is necessary even after reading the story told by the bread, because if several factors are out of adjustment, time and patience are required for success.

Therefore, in conclusion, if the troubles which are made the basis of flour complaints are considered in the light of hydrogen-ion concentration or bread age, by far the greater majority can be easily solved. If this fundamental principle is recognized when trouble arises, a stunning blow can be dealt the situation by the proper balance of the old factors on one side against the young factors on the other side. Indeed, bread age, which may be influenced by so many factors regulating the hydrogen-ion concentration, is an extremely simple idea; but its recognition is imperative to successful bread baking.

EFFECT OF STORAGE ON BAKING QUALITY OF COMMON AND DURUM WHEATS

By C. E. Mangels

Agricultural Experiment Station, Fargo, North Dakota

(Read at the Convention, June 10, 1924)

The effect of storage on baking quality of wheat and flour has received some attention from investigators, but practically all of the storage studies deal with wheat of the common or vulgare type. Very few data are found on the effect of storage on durum wheats and flour.

A general impression exists that both wheat and flour improve in storage, and this is probably true under certain conditions. A review of the literature indicates that studies on this point have been rather limited.

C. E. Saunders (1) and Shutt (2), of the Ottawa station, studied the effect of storage on the baking quality of wheat and flour. Saunders found that both wheat and flour improved in water absorption and in shape of loaf when stored over long periods. The author also states "In regard to loaf volume some irregularities occurred for which no satisfactory explanation can be offered at present."

Shutt made chemical studies on the wheat and flour samples used by Saunders and found that total protein and gliadin tend to increase in storage but the difference is hardly sufficient to be of significance. No durum wheats were used by Saunders and Shutt. Saunders in a later report (3) gives the following conclusions: "The table and outline drawings show clearly that most of these varieties of wheat are improved very considerably in baking qualities by long storage, either as wheat or as flour. The highest baking strength was attained when the wheat was stored about three or four years. When the material was stored as flour the changes were more rapid and the highest baking strength was reached in two or three years. It appears that by storing the material as flour a higher baking strength can be obtained than is possible when the material is stored as wheat. Ultimately deterioration sets in, rather earlier with the flour than with the wheat, but it is evident that storage under good conditions is safe for at least ten years." The author also states "In spite of all the precautions taken the results show a number of provoking irregularities," and these irregularities are ascribed to variation in quality of yeast. The wheat and flour samples in this case were stored in an unheated room.

Snyder (4) stored flour milled from spring and winter wheat in a dry, well-ventilated warehouse, four, eight, and twelve months, and compared the stored flour with fresh flour milled from similar wheat.

Analyses and baking tests indicated that flour stored under these conditions shows no deterioration in quality, and a slight improvement was noted in size and color of loaf.

Swanson, Willard, and Fitz (5) stored flour in steam heated and unheated rooms for comparatively long periods. They find loss of moisture, but otherwise no significant change in baking quality or composition.

Stockham (6) reports improvement in baking quality of flour stored in a humid cabinet at 85-95°F. for three weeks as compared with original and with flour stored in a dessicator over sulphuric acid.

Ladd (7) reports results of a storage test with durum patents and clears. These flours were stored for three months during hot summer weather (May 17 to August 17, 1911). Six out of seven samples show a loss in volume, but absorption was higher for all samples, and color of the clear flours showed marked improvement.

H. L. White (8) found that flour stored for two years showed no considerable increase in acidity. The hard wheat flours maintained their baking qualities better than the durum flours, but both showed decrease in volume.

Experimental

This paper will be limited to a study of the change in loaf volume during storage. The figure for loaf volume is obtained by actual measurement, and is not dependent on judgment such as color and texture scores. The loaf volume, furthermore, is perhaps the best indicator of baking strength. Time was not available for extensive chemical studies on these samples, and the chemical analyses made do not show differences which can be regarded as significant, except possibly in case of stored flour.

I

Twelve two-bushel lots of wheat from the 1921 crop were obtained from different state demonstration farms. Four lots were hard red spring wheat, and eight were durum wheat. Table I gives the variety, grade, test weight, and other data on these samples. The moisture content of the wheat as received was in no case sufficiently high to cause heating in storage. The wheat from the 1921 crop was high in protein and only four samples contained less than 13 per cent protein. The sample of durum from Hazen was lowest, with a protein content of 9.89 per cent.

TABLE 1

STORAGE SAMPLES FROM 1921 CROP

Sample No.	Location in North Dakota	Variety	Grade	Test weight	Moisture content* when received	Protein N×5.7† (13.5% basis)
21-9-25	Dawson	Marquis	4 D.N.S.	54	10.4	16.80
21-9-27	Tioga	P. Fife	3 D.N.S.	55	10.2	16.28
21-9-63	Hazen	Marquis	1 D.N.S.	58	9.5	11.73
21-10-3	Webster	Marquis	2 D.N.S.	57	10.5	16.67
21-9-26	Tioga	Monad	2 A.D.	58	9.3	13.55
21-9-28	Hoople	Monad	3 A. D.‡	56	11.3	13.26
21-9-61	Hatton	Monad	4 A.D.	54	12.0	12.90
21-9-62	Hazen	Monad	1 A.D.	62	10.0	9.89
21-9-64	Underwood	Common	2 A.D.§	61	10.0	11.43
21-9-65	Underwood	Monad	2 A.D.	59	9.0	14.11
21-10-4	Webster	Monad	2 A.D.	58	12.2	13.94
21-10-5	Webster	Kubanka	1 A.D.	60.5	11.3	13.67

*Moisture in wheat by Brown-Duval tester.
†Protein content of straight flour (first milling).
‡7% damage.
§9% H. R. S.

The first milling and baking of these samples was done in October, 1921. For the milling and baking test, 1500 grams of cleaned wheat was milled into straight flour on a small Allis experimental mill. Two bakings were made on each sample and the average of two tests was used. The wheat was stored in an unheated elevator and portions were withdrawn at intervals for additional milling and baking tests. Eight milling and baking tests have been made on these samples, extending over approximately two years. The dates at which baking tests were made are shown in Tables II and III, with loaf volumes obtained for each baking.

TABLE II

Effect of Storage of Wheat on Loaf Volume, Common Wheats, 1921 Crop

No. of milling	Date of milling and baking	Common wheats Marquis 21-9-25	P. Fife 21-9-27	Marquis 21-9-63	Marquis 21-10-3	Average
1	Oct., 1921	2648	2265	2228	2303	2361
2	Jan., 1922	2655	2225	2115	2225	2305
3	June, 1922	2555	2200	2073	2325	2288
4	Aug., 1922	2600	2285	2133	2353	2343
5	Oct., 1922	2605	2198	2203	2403	2352
6	Feb., 1923	2633	2303	2125	2475	2384
7	June, 1923	2660	2385	2413	2645	2521
8	Sept., 1923	2615	2197	2272	2432	2379

Discussion.—Marquis sample 21-9-25 gave the largest volume, and with the exception of the low volume on the third baking has shown remarkable consistency in loaf volume. Sample 21-9-27 (Power Fife) shows improvement over original volume in fourth, sixth, and seventh bakings, but these two samples apparently have neither increased nor decreased in quality as shown by loaf volume. Sample 21-9-63 shows considerable variation in loaf volume, but only sample 21-10-3 can be said to show a decided tendency toward improvement in volume. These data indicate that hard red spring wheat shows little or no change when stored under the conditions specified.

The durum wheats show quite different results. Comparing the first baking with the eighth baking, five samples of durum have shown distinct improvement in loaf volume. All samples of durum have shown an increase over the original volume in one or more bakings. Six lots of durum show a decided loss in volume on the second baking, but with one exception all samples show an increase over the original volume on the third baking. The durums appear to be continually undergoing a change, but the change is not uniform. In some cases the durum wheats appear to reach a maximum and then tend to decrease.

TABLE III

EFFECT OF STORAGE OF WHEAT ON LOAF VOLUME, DURUM WHEATS, 1921 CROP

No. of milling	Date milled and baked	Monad 21-9-26	Monad 21-9-28	Monad 21-9-61	Monad 21-9-62	Common 21-9-64	Monad 21-9-65	Monad 21-10-4	Kubanka 21-10-5	Average
1	Oct., 1921	1805	1790	1885	1448	2088	1355	1533	1568	1684
2	Jan., 1922	1575	1565	1603	1205	1583	1253	1660	1660	1513
3	June, 1922	1963	2138	2200	1555	2078	1645	2093	1975	1956
4	Aug., 1922	2040	1985	2205	1448	2105	1660	2053	1793	1911
5	Oct., 1922	1828	2070	2043	1678	1860	2205	2073	2018	1972
6	Feb., 1923	1693	1910	2120	1705	1733	2238	1878	1883	1795
7	June, 1923	1955	2185	2060	1915	1853	2460	1983	2268	2085
8	Sept., 1923	1702	1932	1782	1600	1570	2275	1820	1865	1818

TABLE IV
AVERAGE DEVIATION IN LOAF VOLUME, STRAIGHT FLOUR OF STORED WHEATS, 1921 CROP

Sample No.	Variety	Average volume 8 bakings	Average deviation
21-9-25	Marquis	2621	27.6
21-9-27	Powers Fife	2257	52.3
21-9-63	Marquis	2195	83.8
21-10-3	Marquis	2396	93.6
Average of 4 samples		....	64.3
21-9-26	Monad	1820	126.4
21-9-28	Monad	1947	147.6
21-9-61	Monad	1987	173.0
21-9-62	Monad	1569	155.3
21-9-64	Common	1859	174.0
21-9-65	Monad	1886	408.4
21-10-4	Monad	1887	163.9
21-10-5	Kubanka	1879	157.3
Average of 8 samples		....	188.2

The durum wheats as compared to the common wheats show greater changes in loaf volume and this is shown by the average deviation in loaf volume (Table III). The average deviation of the eight durum samples is 188.2 as compared to 64.3 for the common wheat.

II

Additional lots of wheat were stored from the 1922 crop and these were handled similarly to those of the 1921 crop. Eight lots of wheat of the 1922 crop were obtained from the station at Fargo and from the Dickinson, Williston, and Langdon Substations. Four lots were hard red spring wheat and four were durum wheat. The data on these samples are given in Tables V, VI, and VII. It will be noted that the lots of wheat from the 1922 crop averaged much lower in protein content than those from the 1921 crop (Table I). None of the four lots of common wheat showed particularly high baking strength. The sample of Kubanka durum from Langdon, however, showed exceptional baking strength for a durum wheat.

Five millings and bakings have been made on these samples, extending from November, 1922, to February, 1924 (Table VI). The common wheats have shown greater variation in loaf volume as compared to common wheats from the 1921 crop, but the average of all four samples indicates a definite tendency to increase in loaf volume. The durums show greater variation in loaf volume, as is shown by the average deviation (Table VII), but the difference between the durum and common wheats is not so marked as in the 1921 crop. Three samples of durum show a decrease in volume similar to 1921 durum on the second baking, which corresponds to second baking on the 1921 crop. Samples 22-10-93 and 22-11-20 tend to increase in volume, while the tendency of the remaining two samples is to decrease.

TABLE V

STORAGE SAMPLES FROM 1922 CROP

Sample No.	Location in North Dakota	Variety	Grade	Test weight	Moisture content* when received	Protein N×5.7† (13.5% basis)
22- 9-67	Fargo	Marquis	5 D.N.S.	50.5	10.2	10.60
22- 9-68	Fargo	Kota	1 D.N.S.	59.5	11.1	11.35
22-10-94	Williston	P. Fife	3 N.S.‡	58.2	10.0	10.45
22-11-20	Langdon	Marquis	1 N.S.	61.0	12.5	10.18
22-10-93	Fargo	Monad	2 A.D.	59.7	10.2	13.22
22-11-22	Langdon	Kubanka	3 Dur.§	59.3	13.4	11.75
22-11-63	Dickinson	Monad	1 A. D.	62.0	10.5	12.61
22-11-62	Dickinson	Kubanka	1 Dur.	61.5	10.8	9.98

*Moisture in wheat by Brown-Duval Tester.
†Protein in straight flour (first milling).
‡5.4% damaged and sprouted kernels.
§6.0% damaged and sprouted kernels.

TABLE VI

EFFECT OF STORAGE ON LOAF VOLUME, WHEAT FROM 1922 CROP

No. of milling	Date milled and baked	Marquis 22-9-67	Kota 22-9-68	P. Fife 22-10-94	Marquis 22-11-20	Av. Common	Monad 22-10-93	Kubanka 22-11-22	Monad 22-11-63	Kubanka 22-11-62	Av. Dur.
1	Nov., 1922	2088	2240	2130	2138	2149	1580	1885	1883	1763	1778
2	Mar., 1923	1780	2000	2070	2165	2004	1508	1970	1528	1525	1633
3	June, 1923	2235	2293	2315	2233	2269	1723	2323	1793	1673	1878
4	Nov., 1923	2267	2317	2367	2290	2308	1695	2227	1615	1507	1761
5	Feb., 1924	2267	2340	2202	2345	2288	1932	2382	1672	1667	1913

TABLE VII

AVERAGE DEVIATION IN LOAF VOLUME, STRAIGHT FLOUR OF STORED WHEATS, 1922 CROP

No.	Variety	Average loaf volume, 5 bakings	Average deviation
22- 9-67	Marquis	2127	154.8
22- 9-68	Kota	2238	95.2
22-10-94	P. Fife	2217	90.4
22-11-20	Marquis	2234	59.0
Average of 4 samples		.....	102.1
22-10-93	Monad	1688	114.8
22-10-22	Kubanka	2157	184.0
22-10-63	Monad	1698	111.8
22-11-62	Kubanka	1627	88.8
Average of 4 samples,		.....	124.8

The hard red spring or common wheats have either practically maintained their original loaf volume or have shown a tendency to improve in loaf volume. While the general tendency of the durum wheats was toward improvement, in some samples there has been a decided change in the opposite direction. The period of storage for the 1921 samples has been approximately two years and the common wheats, as has been noted, have not deteriorated in that time. Can we expect common wheats to retain indefinitely their quality as indicated by loaf volume when stored under similar conditions? The baking data from a lot of Fife wheat from the 1909 crop (Table VIII) suggest that the common wheats will ultimately lose baking quality. The loaf volumes obtained upon this sample up to and including baking made in April, 1916, were very consistent, but in February, 1917, there was a decided loss in volume. These data indicate that wheat eventually deteriorates in baking quality.

TABLE VIII

EFFECT OF LONG STORAGE ON WHEAT FROM 1909 CROP

Date of baking	Volume
November, 1910	2670
February, 1914	2740
February, 1915	2705
April, 1916	2690
February, 1917	2350
August, 1922	2348

III

Effect of Storage on Straight Flour

One bushel of each of the lots of wheat from the 1922 crop used for wheat storage studies was milled to straight flour on the large experimental mill. These flours are not strictly comparable to those

milled on the small experimental mill. The first baking on these lots of flour was made in December, 1922. Each lot of flour was then divided into two equal portions. One portion was stored in a cabinet in the laboratory, which is steam heated. This is hereafter designated as "warm storage." The other portion was placed in the elevator which was unheated and this is hereafter designated as "cool storage." During the hot summer months both storage rooms were approximately the same temperature but the difference if any was in favor of the "cool storage" samples, as the elevator has a north exposure. Baking tests were made on these lots of flour in March, June, and October, 1923. The results are shown in Table IX.

Discussion.—The baking tests made in March, 1923, indicate that the common wheat flours in cool storage have not changed to any extent, but those in warm storage show evidence of slight deterioration; while the durum flours in both cool and warm storage show deterioration and the durums in warm storage a decided decrease in loaf volume.

The baking tests made in June, 1923, indicate distinct improvement for the common wheat flours in cool storage, and with the exception of one sample the warm storage flour shows improvement over previous baking. The changes shown at this baking over the previous baking may possibly be due to other causes than change in flour quality.

The November bakings show marked decrease in the average loaf volume of both common and durum wheats, and in nearly all cases a decrease in volume as compared to previous bakings. The decrease in the cool storage common wheat flour samples is not large, but it certainly indicates deterioration. The decrease in average volume of common wheat flour in warm storage is quite marked, and the low average is due to the marked decrease in loaf volume of sample 22-11-71. The decrease in volume in durum flours is greater than the decrease in common wheats. The largest decrease occurs in flours in warm storage. The baking data on the Kubanka sample 22-11-75 are interesting. This flour, as already noted, showed unusually good baking quality for durum wheats and maintained its loaf volume in warmer storage very well until the final baking.

The data indicate that warm storage is detrimental to both common and durum wheat flours. Durum flours show relatively greater deterioration than common wheat flours under both conditions of storage.

TABLE IX

CHANGES IN LOAF VOLUME OF STRAIGHT FLOUR DURING STORAGE

			March, 1923		June, 1923		November, 1923	
Sample number	Variety	Freshly milled flour, December, 1922	Cool storage	Warm storage	Cool storage	Warm storage	Cool storage	Warm storage
Common wheat								
22-11-70	Marquis	2033	2100	2050	2208	2118	1955	1805
22-11-71	Kota	2113	2150	1990	2223	1800	2000	1585
22-11-73	P. Fife	2163	1993	1938	2115	2023	2012	1845
22-11-74	Marquis	2223	2088	1998	2078	2055	2017	1902
Average 4 samples		2133	2083	1994	2156	1999	1996	1784
Durum								
22-11-72	Monad	1600	1463	1350	1388	1358	1287	1122
22-11-75	Kubanka	2015	1950	1833	2090	1968	1755	1140
22-11-76	Kubanka	1448	1093	918	1115	1078	965	980
22-11-77	Monad	1695	1658	1215	1445	1330	1310	970
Average 4 samples		1690	1541	1329	1510	1435	1329	1053

Chemical studies were made on these flours after the November, 1923, baking, but these studies do not throw much light on the cause of deterioration. Some of the flours (particularly those in warm storage) have increased in titratable acidity, but the increase is not marked. Some of the flours have also shown a small increase in amino-nitrogen, and in general the diastatic activity of the flours in storage showed an increase. Further studies on the causes of deterioration are contemplated.

Summary

1. Common wheats of the 1921 crop show little change in loaf volume after storage for two years, and if any change has taken place, it is in the direction of improvement.

2. Durum wheats of the 1921 crop gave more variable results than common wheats. While the general tendency of durum wheats in storage was to increase in loaf volume, some samples show changes in the opposite direction.

3. Wheats in storage from the 1922 crop show results similar to those of the 1921 crop but the difference between common and durum wheats was not so marked.

4. Warm storage is more detrimental to flour quality than cool storage. After 11 months storage all lots of flour showed some deterioration, but the durum flours showed relatively greater deterioration than the common wheat flours.

Bibliography

1. (a) Canadian Experimental Farms Report 1907, pp. 219-223.
   (b) Canadian Experimental Farms Report 1909, pp. 204-208.
   (c) Canadian Experimental Farms Report 1910, pp. 167-170.
2. Canadian Experimental Farms Report 1911, pp. 168-171.
3. Bulletin 97, pp. 28-38. Department of Agriculture, Dom. of Can. (1921).
4. Minnesota Agricultural Experiment Station Bulletin 85, pp. 213-217.
5. Kansas Agricultural Experiment Station Bulletin 202 (1915).
6. North Dakota Special Bulletin. Vol. 2, No. 7, p. 118 (1912).
7. North Dakota Special Bulletin. Vol. 1, No. 36, pp. 414-415 (1911).
8. North Dakota Report of Food Commissioner, pp. 140-143 (1911).

Acknowledgment

The writer wishes to acknowledge the collaboration and assistance in this study of Thomas Sanderson, miller of this department. All milling tests and part of the baking tests were made by Mr. Sanderson.

EFFECT OF GERMINATION ON THE ALEURONE LAYER

By Edmund Baron Bennion

National Bakery School, London, England

(Received for publication May 1, 1924)

The germination of the gramineae is a question which has been fairly thoroly investigated by Brown and Morris with special regard to barley, and by Haberlandt in the case of rye. Haberlandt attempted to show that the aleurone layer does not belong entirely to the reserve food system of the seed, but that during germination the cells composing this layer function as a glandular tissue and secrete diastase into the adjacent starch-containing portion of the endosperm. The experiments were carried out on rye and Haberlandt considers that the aleurone layer in all the grasses functions in a similar way.

Brown and Morris in their earliest investigations noticed just as had Haberlandt, that dissolution of the endosperm starch during germination takes place more readily in certain definite directions than in others, the rate of progress being more rapid in the peripheral portions of the dorsal side of the grain, immediately under the aleurone layer.

However, subsequent investigations seemed to show that the diastatic action took place only after the cell walls of the starch containing endosperm tissue had been attacked by the cellulose dissolving enzyme, since the diastatic enzyme possesses a lower rate of diffusibility than the cytohydrolyst. Accordingly it was decided to carry out experiments to see if the views expressed by Brown and Morris were applicable to wheat.

The aleurone layer from a wheat berry which had been germinated so far as to have its starchy endosperm completely disintegrated, was separated from the bran. It was then thoroly washed in distilled water many times and placed on a very thin layer of wheat starch spread on a moistened filter paper. At the end of 24 hours a very considerable amount of action on the starch was found to have taken place.

Next, a section of aleurone layer from an ungerminated kernel was left in contact with moistened starch, but not until the end of 96 hours was any considerable amount of action noticeable.

It must be remembered that in the first case the aleurone layer had been in contact with a portion of the endosperm, which at the stage of growth at which the dissection was made, was highly charged with accumulated diastase, and it would be strange if the tissues of the aleurone layer did not retain, especially in their intercellular spaces, some of the enzyme, which it would be very difficult to remove by long continued washing.

Also, in the second case, the aleurone layer could not be completely separated from all portions of the endosperm so that in this case diastatic action would be set up from this cause, and having to develop would take considerably longer time to effect a noticeable difference. The starch employed was tested by means of Pavey's solution, and was found to have a very low Lintner value, so that diastasis would be started from that cause alone.

Starch obtained by washing out gluten and subsequently well washed with distilled water, was next dried for several hours in a steam oven, then transferred to a moist filter paper and moistened with distilled water. A thin section of the aleurone layer was taken from an ungerminated wheat berry, moistened, and placed on top of the starch and left for 8 days, and maintained in a moist condition. At the end of this time the starch was examined. No action had taken place on the starch that could be observed or detected by chemical examination.

From these observations, coupled with those of Brown and Morris, it seems obvious that there is no justification in suspecting that the cells of the aleurone layer are glandular in the same sense as the epithelial cells of the scutellum, hence it is as well to adhere to the opinion that diastase accumulated in seeds of grasses owes its origin exclusively to the secretory glandular cells forming the scutellar epithelium and not to the aleurone cells.

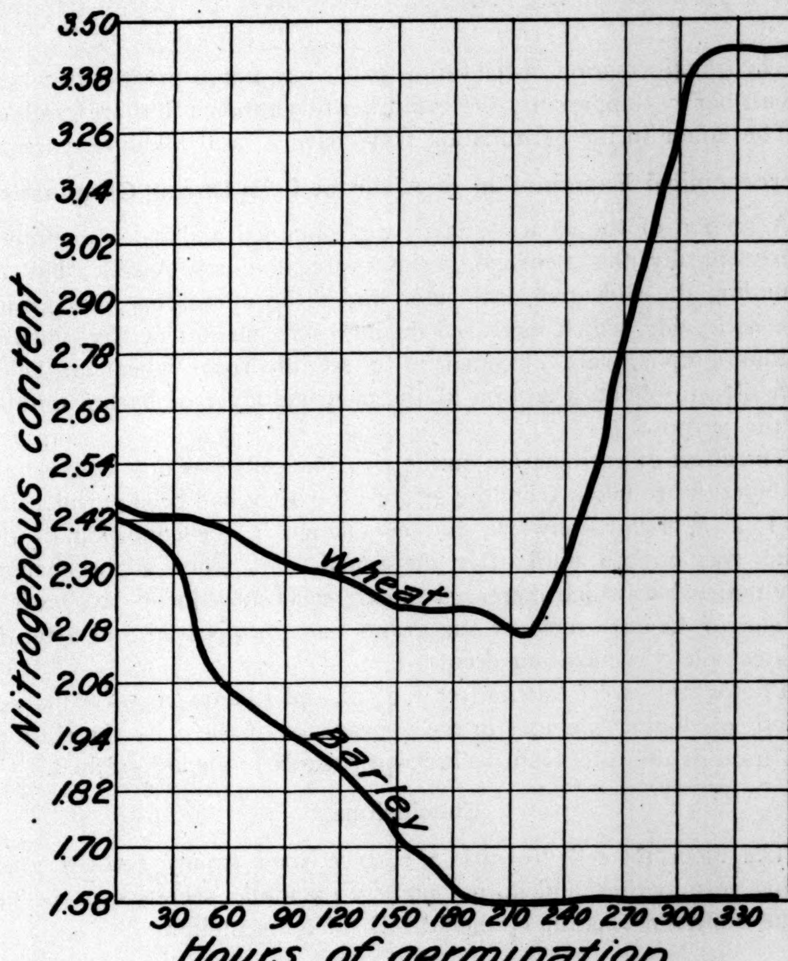
The next section of the research was the effect of germination on the nitrogen content and aleurone cells. The variety of barley employed was Chevalier, and the barley kernels were germinated for 30 hours to begin with, the time being increased by 15-hour periods. Durum wheat was likewise used.

The nitrogen content of the ungerminated barley and wheat was determined, using the Kjeldahl method, and subsequently the nitrogen content of the germinated grains after definite periods of germination. The nitrogen content was found to diminish after 30 hours germination, and very considerably after 45 hours. Brown and Escombe state that when wheat germinated, rapid action of the enzymes is promoted by early hydrolysis of cell membranes of the endosperm by cytase, which is secreted by the aleurone cells. Prescott in "Enzymes and Their Applications" says that during germination the grain secretes, besides amylase, other active substances, among them peptase which transforms the albuminoids into amides.

On reading the above, together with other literature on the subject, it occurred to the writer, that as enzyme action is so prominent during germination, causing conversion of albuminoids to amides, some of

these amides may be converted into a soluble form and go into solution, thus diminishing the nitrogen content; but also if there were a suitable active enzyme present, this degradation of albuminoids might go a step further than amides, with the production of ammonia, which would be evolved as such or absorbed by the moisture present. Consequently, in the germination trays, red litmus papers were placed on top of the Calais sand which covered the seeds, and the whole mass was moistened.

At the end of 24 hours no change was noticed, but after 45 hours germination at 15°C. the litmus papers turned blue. This was considered to be due to ammonia which must have been evolved, as the sand employed had been treated with concentrated hydrochloric acid for some time, and washed free from acid, then ignited for many



hours in a suitable furnace, and was absolutely free from alkali. The evolution of ammonia and conversion of red litmus paper to blue, was rapid during the first 45 hours, but gradual during the succeeding 360 hours.

The diminution of nitrogen content in barley and wheat is given in the following table. The results are shown graphically in the figure.

BARLEY

Period of germination, hrs.	...	0	30	45	60	75	90	105	120
Nitrogen, per cent........	...	2.43	2.35	2.16	2.07	1.99	1.97	1.93	1.86
Period of germination, hrs.	135	150	165	185	210	240	270	300	360
Nitrogen, per cent........	1.82	1.73	1.60	1.59	1.58	1.58	1.58	1.58	1.575

WHEAT

Period of germination, hrs.	...	...	...	0	30	45	75	96	120
Nitrogen, per cent........	...	...	...	2.45	2.42	2.42	2.37	2.31	2.29
Period of germination, hrs.	...	...	...	150	191	216	267	312	330
Nitrogen, per cent........	...	...	...	2.25	2.22	2.15	2.60	3.40	3.41

The transformation of the litmus paper was not as great with wheat as with barley—apparently the evolution of ammonia is more gradual.

The liquor in the germination trays gave a faint alkaline reaction.

Microchemical Examination of Aleurone Cells During Germination

A section of the aleurone layer was obtained and when examined microscopically the aleurone grains were distinctly visible, but on examining the slide two days later under the microscope, the grains were noticeable, which increased during each subsequent day, until at

Photographs were obtained of a section from wheat, it being impossible to obtain a section of the aleurone layer of barley suitable for the purpose.

The effect of germination on the aleurone cells was now considered, and layers were taken from the grains after they had been germinating for 1, 2, 3, 4 days onward, and no change in the condition of the grains was noticed until after the fourth day, when slight changes were noticeable, which increased during each subsequent day, until at the end of 12 days most of the grains had disappeared and after 16 days complete vacuolation occurred.

Photographs were taken after 4, 8, 12, and 16 days, as these marked periods of distinct changes in the appearance of the cells, the state of transition of the cells from fullness to vacuolation being gradual.

Conclusions

The aleurone cells furnish a reserve food supply for the grain during germination, and do not possess glandular secretive properties in the same sense as the epithelial cells of the scutellum.

They do not seem to function as a food supply until the seeds have germinated for six days, at the end of which time they gradually begin to disappear and vacuolation is almost complete at the end of 12 days, when the germination is carried out in a special tray at a temperature of 15°C.

The nitrogen content of wheat and barley decreases gradually after the grains have been germinating for 30 hours, the subsequent increase in nitrogen content of wheat being due to the complete using up of the starch in the endosperm during germination. During early stages of germination considerable quantities of ammonia are evolved.

REPORT OF THE COMMITTEE ON METHODS OF ANALYSIS FOR THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

Submitted by L. H. Bailey, Chairman

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

M. R. Warren C. E. Mangels
C. B. Kress C. H. Bailey

(Read at the Convention, June 12, 1924)

It was decided by the committee that the work this year would be confined to a consideration of the methods for determining moisture, ash, and nitrogen in cereal products. C. B. Kress and M. R. Warren were selected to study methods for nitrogen determinations. J. R. Hess and C. H. Bailey to study methods of determining ash, and C. E. Mangels and L. H. Bailey to study the methods of determining moisture.

It was suggested by Mr. Mangels that before collaborative work was undertaken a survey should be made to ascertain which laboratories were best equipped for making the various determinations. Accordingly, a questionnaire was sent to approximately one hundred and twenty-five members of the association, and a summary of replies to this questionnaire was furnished the various members of the Committee on Methods, to aid them in selecting their collaborators.

The committee desires to express its appreciation to the various collaborators for their hearty co-operation and for the services rendered.

Nitrogen

The work of nitrogen determination was divided by the committee. It was suggested that this committee give consideration to the development of a method more rapid than the present official method; and as an aid in shortening the time of making the determination, it was suggested that perchloric acid or a perchlorate be employed. C. B. Kress conducted this investigation. The results of this collaborative study are shown in Table I. It will be noted from the table that each of the different factors was made a variable in different determinations. From these results Mr. Kress believes the following to be the best method for determining nitrogen in wheat and flour when perchloric acid or potassium perchlorate is used:

One gram sample—20 cc. concentrated sulphuric acid, 6 grams dry sodium sulphate, 0.2 grams copper sulphate, 2 cc. 60 per cent perchloric acid or 1.7 grams potassium perchlorate. Digest slowly at first, then use a good strong flame that will distill 100 cc. of water in about twenty minutes; the sample will clear in from 5 to 10 minutes. Continue the digestion for a total of 30 minutes.

It appears that a slight excess or deficiency in the amount of perchloric acid influences this test very strongly.

In view of the above results, the committee recommends that no further work be done at this time with the use of perchloric acid or perchlorates.

M. R. Warren studied modifications of the official method. These collaborative results are given in Table II. It will be noted from this table also that several factors were made variables in different determinations. The determinations which seemed to yield the best results are underlined.

It will be noted that while the amount of chemicals used might affect the result, they had less influence than the time of digestion. Columns 2X and 7X are calculated from columns 2 and 7. It was ascertained that the standard acid used by collaborators 2 and 7 did not check with the standard acids used by the other collaborators, but when the results were calculated on the same basis as the other collaborators, much better agreement was secured. Each collaborator submitted a sample of the standard acid that he was using. Each acid was titrated against a standard sodium hydroxide solution, presumably n/10 strength. This hydroxide solution was let equal 100, or in other words, 100 cc. of hydroxide should neutralize 100 cc. of acid n/10 strength. With this alkali as a standard, all the acids were titrated and calculated to n/10 strength. The following results were shown:

Collaborator	Acid
1	100.00
2	98.25
3	100.00
4	100.00
6	100.50
7	98.00
8	.....

It is not contended that collaborators 2 and 7 are incorrect or that 1, 3, and 4 are correct, but granting that the majority are more likely to be right, the results of Nos. 2 and 7 were multiplied by factors and tabulated under columns 2X and 7X respectively.

The averages, maximums and minimums, as well as conclusions, are drawn from 2X and 7X, instead of from 2 and 7.

The moisture content was the same in all samples sent out, so all results were figured to original moisture found by each individual collaborator. This was done to eliminate any error from a moisture test. The collaborators found the following moisture content in sample when opened:

Collaborator	Moisture, %
1	11.30
2	11.00
3	10.95
4	11.00
6	10.72
7	11.23

Type of heat used and intensity of heat, as determined by the time necessary to evaporate 100 cc. of water in a 250 cc. beaker, starting with boiling water.

For digestion

Collaborator	Electricity	Gas	Time in minutes
1	x	..	23
2	x	..	21
3	..	x	30
4	..	x	16½
6	..	x	12
7	..	x	13½
8	x	..	27

For distillation

Collaborator	Electricity	Gas	Time in minutes
1	x	..	15
2	x	..	23
3	..	x	25
4	..	x	14
6	..	x	10
7	..	x	20
8	x	..	33

TABLE I

PROTEIN DETERMINATIONS WITH PERCHLORIC ACID

Amount sample gms.	H_2SO_4 cc.	Sodium sulphate gms.	$HClO_4$ 60% cc.	$KClO_4$ gms.	$CuSO_4$ gms.	Total time min.	Time to clear, in minutes: 9	2	7	% Protein calculated to 13½% moisture: 9	2	7
1	20	6	2	...	.2	20	5	10	10	12.00	12.65	12.14
1	20	6	2	...	.2	25	5	10	9	12.12	12.65	12.06
1	20	6	2	...	.2	30	6	10	9	12.12	12.70	12.18
1	20	6	2	...	.2	35	6	10	10	12.12	12.65	12.07
1	20	6	2	...	.2	40	6	10	9	12.12	12.60	12.11
1	20	6	2	...	.2	60	6	10	9	12.20	12.40	12.26
1	20	6	1	...	.2	25	17	17	Brown	11.85	11.30	.....
1	20	6	2	...	.2	25	8	10½	9	12.12	12.95	12.07
1	20	6	3	...	.2	25	7	9	8	2.8	8.15	10.21
1	20	6	4	...	.2	25	7	7	8	3.0	6.94	9.14
1	20	6	5	...	.2	25	7	6½	8	3.7	4.96	8.12
1	20	6	..	.5	.2	25	Brown	24½	..	11.95	12.10	.....
1	20	6	..	1	.2	25	22	23	..	12.25	11.95	.....
1	20	6	..	2	.2	25	8	10	..	12.00	12.70	.....
1	20	6	..	3	.2	25	3	9	..	.65	9.95	.....
1	20	6	..	4	.2	25	4	..	..	.15	.....	.....
2	20	6	2	...	.2	25	Amber	Amber	Amber	11.60	11.65	.....
2	25	6	3	...	.2	25	Amber	Amber	Amber	11.75	12.20	.....
2	25	6	4	...	.2	25	11	11	13	12.10	12.50	12.09
1	25	6	2	...	.2	25	8	10	12	12.0	12.0	12.11
1	20	4	2	...	.2	25	5	10	10	11.9	12.2	12.0
1	20	6	2	...	.2	25	6	10	13	12.15	12.8	12.0
1	20	8	2	...	.2	25	7	10	10	12.05	12.0	12.17
1	20	6	2	...	.2	25	6	7½	10	12.19	12.25	12.27
1	20	6	2	...	.5	25	5	7	10	12.15	12.25	12.00
1	20	6	2	...	1.0	25	5	6½	10	12.19	12.42	12.27
Moisture when opened........										10.9	10.9	10.9
Time to distill 100 cc.—digesting burner, min........										18	15	28
Time to distill 100 cc.—distilling burner, min........										15	15	37

TABLE II

STUDY OF NITROGEN DETERMINATION BY MODIFICATIONS OF OFFICIAL A. O. A. C. METHOD

Amount sample	Sodium sulphate	Red mercuric oxide	Time in minutes	Caustic	Sodium sulphide	1	2	3	4	6	7	8	2x	7x	Average	Maximum	Minimum
1	7.5	.7	120	Excess	25	12.90	12.70	12.95	12.64	12.64	12.77	12.62	12.95	13.02	12.82	13.02	12.62
1	7.5	.7	120	Excess	25	12.86	12.80	12.94	12.68	12.66	12.77	12.78	13.05	13.02	12.86	13.05	12.66
1	7.5	.7	120	Excess	25	12.95	12.75	12.95	12.72	12.54	12.77	12.78	13.00	13.02	12.99	13.02	12.54
1	7.5	.7	120	Excess	25	12.88	12.80	12.95	12.64	12.50	12.69	12.62	13.05	12.94	12.80	13.05	12.50
1	5.0	.7	120	Excess	25	12.90	12.80	12.86	12.64	12.54	12.77	12.78	13.05	13.02	12.83	13.05	12.54
1	7.5	.7	120	Excess	25	13.00	12.75	13.00	12.72	12.54	12.77	12.78	13.00	13.02	12.87	13.02	12.54
1	10.0	.7	120	Excess	25	12.95	12.75	12.90	12.70	12.69	12.77	12.62	12.95	13.02	12.83	13.02	12.62
1	5.0*	.7	120	Excess	25	12.90	12.85	12.95	12.76	12.64	12.77	12.78	13.10	13.02	12.88	13.10	12.64
1	7.5*	.7	120	Excess	25	12.90	12.85	12.95	12.72	12.62	12.85	12.70	13.10	13.10	12.87	13.10	12.62
1	10.0*	.7	120	Excess	25	13.00	12.85	12.95	12.75	12.48	12.85	12.62	13.10	13.10	12.86	13.10	12.48
1	7.5	.5	120	Excess	20	12.95	12.70	12.82	12.75	12.49	12.69	12.62	12.95	12.94	12.79	12.95	12.49
1	7.5	.7	120	Excess	25	12.95	12.80	13.05	12.72	12.51	12.77	12.86	13.05	13.02	12.88	13.05	12.51
1	7.5	.9	120	Excess	30	13.00	12.65	12.90	12.72	12.48	12.69	12.78	12.90	12.94	12.82	13.00	12.48
1	7.5	.5a	120	Excess	20	13.00	.....	.....	12.76	12.80	12.60	12.70	.....	12.85	12.82	13.00	12.70
1	7.5	.7a	120	Excess	25	12.95	.....	.....	12.75	12.75	12.43	12.78	.....	12.68	12.78	12.95	12.68
1	7.5	.9a	120	Excess	30	12.95	.....	.....	12.78	12.70	12.60	12.78	.....	12.85	12.81	12.95	12.70
1	7.5	.1b	120	Excess	..	13.00	12.65	12.90	12.59	12.68	12.77	12.70	12.90	13.01	12.83	13.01	12.59
1	7.5	.25b	120	Excess	..	13.00	12.70	12.88	12.61	12.48	12.85	12.70	12.95	13.10	12.82	13.10	12.48
1	7.5	.5b	120	Excess	..	12.90	12.55	12.65	12.59	12.40	12.85	12.78	12.80	13.10	12.89	13.10	12.40
1	7.5	.7	30	Excess	25	12.80	12.50	11.91	12.53	12.36	12.43	12.38	12.75	12.68	12.63	12.80	11.91
1	7.5	.7	45	Excess	25	12.80	12.55	12.55	12.59	12.62	12.60	12.46	12.80	12.85	12.67	12.85	12.46
1	7.5	.7	60	Excess	25	12.95	12.60	12.70	12.70	12.41	12.60	12.54	12.85	12.85	12.86	12.95	12.41
1	7.5	.7	75	Excess	25	13.00	12.75	12.78	12.76	12.55	12.77	12.78	13.00	13.02	12.84	13.02	12.55
1	7.5	.7	90	Excess	25	13.00	12.80	12.95	12.67	12.59	12.77	12.70	13.05	13.02	12.85	13.05	12.59
1	7.5	.7	105	Excess	25	13.00	12.65	12.97	12.72	12.77	12.77	13.02	12.90	13.02	12.91	13.02	12.72
1	7.5	.7	120	Excess	25c	13.00	12.50	.....	12.72	12.54	12.77	12.62	12.75	13.02	12.72	13.02	12.54
1	7.5	.7	120	Excess	25c	12.90	12.70	.....	12.72	12.53	12.77	12.78	12.95	13.02	12.82	13.02	12.53
1	7.5	.7	120	Excess	25	13.00	12.75	12.92	12.69	12.75	12.77	12.94	13.00	13.02	12.90	13.02	12.69

Zinc was used to reduce lumping in all but the last, and the third from the last determinations in which pumice was used. Water (250 cc.) was used in the distilling flask; 25 cc. H_2SO_4 was used in digesting except in first two cases, when 15 and 20 cc., respectively, were used, and in the fourth case when 30 cc. was used.

*Potassium sulphate used instead of sodium sulphate.

(a) Yellow mercuric oxide; (b) copper sulphate; (c) potassium thiosulphate.

Preferred Methods of Collaborators

Collaborator I. Sample 1 gram 25 cc. H_2SO_4, 7.5 grams sodium sulphate, 0.7 gram mercuric oxide red; 2-hour digestion, 25 cc. sodium sulphide and zinc. We get our maximum more consistently using this method.

Collaborator II. We believe the modification found to give the maximum results should be adopted as standard. Then, if lack of time or any other reason makes it necessary for a departure from the standard method, the chemist should determine the average variation of his results from those given by the standard method and add the difference before reporting.

Collaborator III. We prefer 1 gram 25 cc. acid and 7.5 grams sodium sulphate, 0.7 gram mercuric oxide, digest 2 hours, use sodium sulphide and zinc.

Collaborator IV. No particular preference for any method giving average of 12.75 protein.

Collaborator VI. We prefer copper sulphate to mercury because it eliminates one reagent and 2-gram charge.

Collaborator VII. We prefer 25 cc. sulphuric acid, 7.5 to 10 grams sodium sulphate, 0.7 grams mercuric oxide red, and 2 hours digestion. There seems to be less chance for error and quicker.

Collaborator VIII. Prefer 25 cc. acid, 7 to 7.5 grams sodium sulphate, 0.7 gram mercuric oxide, 75- to 90-minute digestion.

It is safe to say that more care should be taken in making up standard solutions. We found that the strength of solutions obtained varied 2½ cc. in each 100 cc. used, or on a wheat containing 12.75 protein, would vary at least 0.3 of one per cent.

Again, when the time factor is studied we find that only one collaborator got maximum results using less than 1¼ hours' digestion. From this we find that nothing less than 75 minutes should be used in digestion and probably 90 minutes is safer.

There is no noticeable difference between sodium and potassium sulphate, red mercuric and yellow mercuric oxides, sodium thiosulphate, and sodium sulphide or zinc and pumice.

As far as the bulb used is concerned, it is the committee's opinion that the long one with double tips is preferable.

Should the committee recommend a definite method, it would be as follows:

1 gram sample
7.5 gram sodium sulphate
0.7 gram mercuric oxide (red)
25 cc. sulphuric acid

digest not less than $1\frac{3}{4}$ hours over burner so adjusted that it will evaporate 100 cc. of boiling water in about 20 minutes. Cool, add water, caustic soda, zinc, and sulphate or thiosulphate, shake and distill until about 200 cc. of distillate is collected.

As there is still considerable difference of opinion among the members as to the most desirable method to use, no definite method is recommended at this time, but it is suggested that further study be made as to the limits of time and materials.

Ash Determinations

The results of the collaborative study on ash determinations are supplied by Dr. C. H. Bailey.

These data were reported by eight collaborators who compared the Bailey and Hertwig method (Cereal Chemistry, Vol. I, p. 82) and the official A. O. A. C. method. Each collaborator supplied his own flour samples. A summary of the results is given in Table III, which should be supplemented with the following comments.

Collaborator 1. Found Bailey and Hertwig method most satisfactory.

Collaborator 2. Observed that with B. & H. method the glycerol-alcohol mixture tended to run over sides of crucible.

Collaborator 3. Used only 5 cc. of glycerol-alcohol mixture with B. & H. method. Found a larger crucible necessary.

Collaborator 4. Reported B. & H. method required only two hours while A. O. A. C. method required six hours.

Collaborator 5. Did not think results warrant adoption of B. & H. method.

Collaborator 6. Found results by the B. & H. method to be higher than by the A. O. A. C. method.

Collaborator 7. Found the B. & H. method to give slightly higher results than the A. O. A. C. method.

Collaborator 8. In results reported in the table the muffle was maintained at a dull red heat, and results were satisfactory on three hours ignition. With a hotter muffle essentially the same results were secured in two hours.

In addition to the eight collaborators who reported their analytical findings, three others commented on their experience with the Bailey and Hertwig method as follows:

Collaborator 9. Had difficulty with the alcohol-glycerol mixture boiling over when the B. & H. method was followed.

Collaborator 10. Experienced a similar difficulty.

Collaborator 11. Expressed a preference for the calcium acetate method rather than the B. & H. method.

Collaborative results are given in Table VIII.

TABLE III

RESULTS OF ASH DETERMINATIONS BY THE BAILEY AND HERTWIG, AND OFFICIAL A. O. A. C. METHODS

Collaborator No.	Sample mark	Bailey and Hertwig method Ash	Time of ignition	Official A. O. A. C. method Ash	Time of ignition
		Per cent	Hours	Per cent	Hours
1	A	0.380	..	0.416	..
		0.382	..	0.428	..
	B	1.240	..	1.301	..
		1.230	..	1.285	..
	C	0.755	..	0.798	..
		0.758	..	0.806	..
2	Patent	0.485	4½	0.482	5
		0.482	..	0.485	..
		0.485	..	.....	..
3	1	0.295	2½	0.304	5½
		0.300	..	0.300	..
	2	0.430	..	0.432	..
		0.430	..	0.434	..
4		0.43	..	0.47	6
5	1792	0.809	2	0.667	17
		0.752	4	.....	..
		0.664	9	.....	..
	1988	0.673	2	0.611	17
		0.638	4	.....	..
		0.594	9	.....	..
	1989	0.477	2	0.450	17
		0.481	4	.....	..
		0.449	9	.....	..
	2001	0.574	2	0.442	17
		0.475	4	.....	..
		0.428	9	.....	..
	2066	0.483	2	0.414	17
		0.457	4	.....	..
		0.417	9	.....	..
	2067	0.512	2	0.457	17
		0.490	4	.....	..
		0.470	9	.....	..
6	1	0.474	5	0.410	14
		0.597	5	0.570	14
7	A	0.399	2–3	0.393	15
		0.415	2–3	0.400	15
	B	0.465	2–3	0.453	15
		0.465	2–3	0.460	15
8	1	1.288	1½	0.500	4½
		1.298	1½	0.504	4½
		0.685	2	0.462	5
		0.771	2	0.468	5
		0.468	3	.....	..
		0.474	3	.....	..

Moisture

Samples were furnished, with directions for making determinations, results were tabulated and conclusions drawn by C. E. Mangels.

The moisture determination is probably more subject to error than that of ash or protein, and the reports of different laboratories often show wide variance in moisture content. Moisture results vary for several reasons, but one of the principal causes of the variation is the

fact that the moisture content of flour is affected by atmospheric conditions. Improper sampling may often be the cause of differences in reports, but it must be admitted, also, that at least part of the trouble lies in the moisture methods used.

The majority of chemists having experience with food and cereal products, now realize that moisture methods are not absolute methods, but are in any case empirical. This means that in order to secure uniform results we must follow a uniform procedure in detail. The devising of a satisfactory moisture method for cereal products presents several difficulties, as the method must not only give uniform results, but must be easily followed by the practical chemist.

Collaborative studies on moisture.—The collaborative studies on moisture methods which are reported in this paper may be divided into three groups: (1) A comparison of vacuum, air, and water ovens as drying apparatus; (2) a study of factors affecting vacuum method; and (3) a study of factors affecting air oven method.

Samples.—The samples of flour were sent out in cork-stoppered six-ounce wide-mouthed bottles. The corks were soaked in hot paraffin before using, and after the stopper was placed both bottle neck and cork were given a coating of paraffin. The stoppers were wired in.

The flour sample used was first mixed for ten minutes in the ten-quart bowl of the Hobart mixer and was then rolled on a sheet of paper for five minutes. The bottles were then filled as rapidly as possible and stoppered as soon as filled. Bottles were completely filled in all cases.

The precautions taken should insure material of uniform moisture content. It is possible, however, that some of the variations in results obtained by different collaborators may be due to loss or gain of moisture in transit, but the method used, it is believed, would reduce this change to a minimum.

Comparison of methods.—For this study only three collaborators were secured, since very few laboratories are now equipped with water ovens. Only one sample was used for this study. The directions sent to collaborators for this study are as follows:

Study of variation of results due to different methods.—Collaborators to determine moisture in samples furnished by the four methods outlined below. All determinations to be made in duplicate and duplicates reported.

I. Vacuum oven method.—Dry 2 grams of flour in a tared metal dish about 40 mm. in diameter by 25 mm. high and provided with a tight fitting cover, to constant weight in a vacuum oven at a pressure of not to exceed 5 cm. of mercury and at a temperature of 100°C.

Replace cover, cool dish in a desiccator, and weigh as soon as dish and contents reach temperature of the air in the laboratory. (First heating to be approximately five hours.)

II. Electric air oven method.—Dry 2 grams of flour in a tared metal dish about 40 mm. in diameter by 25 mm. high and provided with a tight fitting cover, to constant weight in an electric oven at a temperature of 105°C. Bulb of thermometer to be on level with sample. Replace cover, cool dish in a desiccator, and weigh as soon as dish and contents reach temperature of the air in the laboratory. (First heating to be approximately five hours.)

III. Use same procedure as in II, but dry at 100°C.

IV. Dry 2 grams of flour in a tared metal dish about 40 mm. in diameter by 25 mm. high and provided with a tight fitting cover, to constant weight in a water oven at the temperature of boiling water (100°C.). (The water in the jacket of the oven to be brought to the boiling point before samples are introduced and maintained at boiling point throughout drying period. Actual temperature of interior of oven to be observed and reported.) Replace cover, cool dish in a desiccator, and weigh as soon as dish and contents reach temperature of the air in the laboratory. (First heating to be approximately five hours.).

The results obtained by collaborators are shown in Table IV. Maximum results in all cases were obtained with the vacuum method. The average of results obtained by drying at 100°C. in the air oven is 0.02 higher than results obtained by drying at 105°C., but the difference in either case is not great. The water oven gives consistently lower results.

TABLE IV

RESULTS FOR MOISTURE DETERMINATIONS BY DIFFERENT METHODS, SAMPLE I

Collaborators	I Vacuum, 100°C.	II Air, 105°C.	III Air, 100°C.	IV Water oven	Interior temp. of water oven
Wm. C. Luckow, Amer. Institute of Baking, Chicago, Ill.	12.50*	12.01	12.09	10.69	100°C.
J. B. Mudge, Jr., Fleischmann Laboratories, New York City	12.66*	12.17	12.20	11.10	94.6
C. E. Mangels, N. Dak. Exp. Sta., Agricultural College, No. Dak.	12.63†	12.31	12.24	11.03	95.5
Average	12.60	12.16	12.18	10.94	....
Maximum	12.66	12.31	12.24	11.10	....
Minimum	12.50	12.01	12.09	10.69	....
Maximum variation	0.16	0.30	0.15	0.41	....

*Freas oven.
†Mojonnier oven.
All air ovens were Freas ovens.

The combination of high temperature, low pressure, and absence of air gives maximum loss in weight. In case of the air oven, the effect of raising temperature is evidently counteracted by increased oxidation of some constituents of the flour, causing a gain in weight. The low results obtained with the water oven are difficult to explain. Two collaborators record the temperature of the interior of the water oven as 94.6° and 95.5°C. respectively. Mangels has found that the electric air oven gives higher results than the water oven even when samples are dried at identical temperatures. The higher results given by the electric air oven may be due to better circulation of air in the oven, but it is more probable that the difference is due to the manner of heating. The heat transmitted to the sample in the water oven is probably almost entirely heat of conduction and convection. The heating units of the electric oven probably produce considerable heat of radiation, which may have greater drying power.

The results obtained by vacuum method average less than 0.50 per cent higher than those obtained by drying in electric air oven, but are more than 1.5 per cent higher than the water oven results.

Study of the vacuum method.—The purpose of this study was to determine the effect of three variables on vacuum oven results: (1) leaving dishes loosely covered (suggested by L. H. Bailey); (2) size of sample, and (3) effect of weighing by difference as compared to weighing samples in tared scoop.

The directions sent to collaborators for this study follow:

All determinations to be made in duplicate and duplicates reported. The work outlined is to secure information on three points: (1) effect of partially covering sample while drying; (2) effect of size of sample; (3) weighing from closed container.

Method I. Place 2 grams of flour in a tared metal dish about 40 mm. in diameter and 25 mm. high and provided with a tight fitting cover. Dry to constant weight in a vacuum oven at a pressure of not to exceed 5 cm. of mercury and at a temperature of 100°C. Covers of dishes to be entirely removed while drying, and to be replaced when sample is placed in desiccator for cooling.

Cool the dish in a desiccator and weigh as soon as the dish and contents reach the temperature of the air in the laboratory.

Method II. Proceed as in Method I, using same weight of sample, but instead of removing covers, dry with covers loosely placed on the dishes. Dishes to be tightly covered when placed in desiccator for cooling.

Method III. Proceed as in Method I, but use 5-gram sample of flour. Use same size dish, covers of dishes to be entirely removed during drying.

Note: For methods I to III it is presumed that samples are weighed as rapidly as possible either directly into tared dishes or weighed in tared scoop and transferred to dishes.

Method IV. Place about 10 grams of flour sample in a weighing bottle and weigh. Weigh by difference into tared metal dishes (same size as preceding methods) samples of approximately 2 grams in size. Dry as in Method I with covers entirely removed during drying.

The following directions apply to all four methods:

(1) After placing flour sample in dish, tap the dish lightly with pencil or spatula, in order to distribute flour evenly over bottom surface of dish.

(2) Initial drying in all cases to be five hours.

(3) In reporting results, report per cent loss after five hours drying and total per cent loss when constant weight is reached.

(4) State whether $CaCl_2$ or H_2SO_4 was used in desiccator.

Two samples of flour were sent to collaborators for this study. Sample No. 2 was a hard red spring patent and Sample No. 3 was a durum patent. The collaborating laboratories are designated by numbers 1 to 6. The results obtained for different methods are given in Tables V and VI for Samples 2 and 3 respectively.

Laboratory No. 5 reported trouble with vacuum oven and could not obtain less than a 12-inch pressure. It will be noted that its results are consistently lower than those obtained by other collaborators. The maintenance of a high degree of vacuum appears to be essential. Collaborators were requested to report loss in weight at 5 hours and maximum loss or constant weight. It will be noted that in most cases 5 hours drying was not sufficient to obtain constant weight, but in some cases the decrease in weight after five hours drying is insignificant. The fact that constant weight is not obtained after five hours drying in many cases indicates the importance of drying a sufficient length of time.

The average of results from loosely covered samples as compared with uncovered, shows that the partially covered samples have lost more weight after 5 hours drying, but the results at constant weight are identical. The maximum variation of the covered samples is 0.62 and 0.96 as compared to 0.36 and 0.80 for the uncovered dishes. The average and maximum variation between duplicates is also greater for the covered dishes. For Sample 2, Laboratories 1, 3, 5, and 6 obtained higher results but the other two laboratories obtained lower results. For Sample 3, Laboratories 3 and 6 obtained higher results for Method II; Laboratories 1 and 2 obtained higher results for Method I, while Laboratory 4 obtained identical results for both methods.

TABLE V

RESULTS OF MOISTURE DETERMINATIONS WITH VACUUM OVEN (SAMPLE No. 2)

	Oven type*	Vacuum maintained	Desiccator reagent	Five-hour drying I	II	III	IV	Constant weight I	II	III	IV
				13.91	14.08	14.01	13.94	13.93	14.09	14.12	13.96
No. 1	F	28-inch	H_2SO_4	13.99	14.05	14.09	13.98	14.07	14.14	14.10	13.99
				13.95	14.07	14.05	13.96	14.00	14.12	14.11	13.98
				13.52	13.59	13.61	13.62	13.65	13.59	13.66	13.71
No. 2	M	5 c.m.	H_2SO_4	13.50	13.42	13.56	13.63	13.65	13.42	13.60	13.77
				13.51	13.51	13.59	13.63	13.65	13.51	13.63	13.74
				13.70	13.90	13.71	13.83	13.86	13.90	13.77	13.91
No. 3	M	1 c.m.	$CaCl_2$	13.63	13.82	13.79	13.59	13.85	13.85	13.82	13.80
				13.67	13.86	13.75	13.71	13.86	13.88	13.80	13.86
				13.56	13.46	13.42	13.60	13.62	13.46	13.59	13.74
No. 4	F	5 c.m.	H_2SO_4	13.54	13.50	13.47	13.66	13.66	13.53	13.63	13.70
				13.55	13.48	13.45	13.63	13.64	13.50	13.61	13.72
				12.43	11.79	12.12	12.28	12.88	12.82	13.02	13.05
No. 5†	F	12-inch	$CaCl_2$	12.27	12.03	12.02	12.17	12.83	12.96	12.98	12.96
				12.35	11.91	12.07	12.23	12.86	12.90	13.00	13.01
				13.77	13.97	13.89	13.94	13.77	13.97	13.89	13.94
No. 6	M	28½-inch	H_2SO_4	13.85	13.92	13.88	14.08	13.85	13.92	13.88	14.08
				13.81	13.95	13.89	14.01	13.81	13.95	13.89	14.01
Average of averages				13.70	13.77	13.75	13.79	13.79	13.79	13.81	13.86
Maximum average				13.95	14.07	14.05	14.01	14.00	14.12	14.11	14.01
Minimum average				13.51	13.48	13.45	13.63	13.64	13.50	13.61	13.72
Maximum variation				0.44	0.59	0.60	0.38	0.36	0.62	0.50	0.29
Average variation between duplicates				0.05	0.07	0.04	0.10	0.05	0.08	0.04	0.08
Maximum variation between duplicates				0.08	0.17	0.08	0.24	0.14	0.17	0.06	0.14

*M=Monjonnier oven.
F=Freas oven.

†Not included in summary.

TABLE VI

RESULTS OF MOISTURE DETERMINATIONS WITH VACUUM OVEN (SAMPLE NO. 3)

	Oven type*	Vacuum maintained	Desiccator reagent	Five-hour drying I	II	III	IV	Constant weight I	II	III	IV
				12.62	12.54	12.64	12.60	12.71	12.59	12.67	12.68
No. 1	F	28-inch	H_2SO_4	12.64	12.57	12.59	12.57	12.73	12.63	12.62	12.59
				12.63	12.56	12.62	12.59	12.72	12.61	12.65	12.64
				12.03	12.00	12.05	12.24	12.08	12.00	12.01	12.29
No. 2	M	5 c.m.	H_2SO_4	12.04	11.90	12.12	12.12	12.07	11.94	12.12	12.23
				12.04	11.95	12.09	12.18	12.08	11.97	12.07	12.26
				12.39	12.62	12.40	12.49	12.87	12.91	12.80	12.92
No. 3	M	1 c.m.	$CaCl_2$	12.45	12.63	12.41	12.38	13.88	12.95	12.82	12.86
				12.42	12.63	12.41	12.44	12.88	12.93	12.81	12.89
				12.36	12.36	12.32	12.34	12.40	12.39	12.45	12.50
No. 4	F	5 c.m.	H_2SO_4	12.32	12.34	12.32	12.32	12.42	12.42	12.35	12.48
				12.34	12.35	12.32	12.33	12.41	12.41	12.40	12.49
				12.31	12.44	12.46	12.47	12.31	12.44	12.46	12.47
No. 5	M	28½-inch	H_2SO_4	12.42	12.66	12.44	12.48	12.42	12.66	12.44	12.48
				12.37	12.55	12.45	12.48	12.37	12.55	12.45	12.48
Average of averages				12.36	12.41	12.38	12.40	12.49	12.49	12.48	12.55
Maximum average				12.63	12.63	12.62	12.59	12.88	12.93	12.81	12.89
Minimum average				12.04	11.95	12.09	12.18	12.08	11.97	12.07	12.26
Maximum variation				0.59	0.68	0.53	0.41	0.80	0.96	0.74	0.63
Average variation between duplicates				0.05	0.08	0.03	0.06	0.03	0.08	0.06	0.05
Maximum variation between duplicates				0.11	0.22	0.07	0.12	0.11	0.22	0.11	0.09

*M=Monjonnier oven.
F=Freas oven.

The results for Method III were surprising. The average results indicate that a 5-gram sample gives equally high results as a 2-gram sample. For Sample 2, three laboratories report very slightly lower results for Method III, while three are slightly higher; and for Sample 3, four of five laboratories show slightly lower results for Method III. Weighing by difference gives slightly higher results for both Samples 2 and 3. The loss of moisture during weighing does probably account for some of the variation in results. This loss will vary with different chemists. If flour samples are weighed rapidly the difference should be negligible, but the results obtained indicate that there is some loss in moisture while the sample is being weighed by the usual method.

The type of vacuum oven used does not appear to be a significant factor in this case, as we have both low and high results from both types of vacuum ovens used.

Summarizing results and comparing Methods II, III, and IV with the standard Method I, we find that II gives approximately the same average results as I, but results show wider variation. This may be due to different interpretation of the term "loosely covered." Method III gives practically the same results as Method I, while Method IV gives higher results than Method I.

Study of the air oven method.—The purpose of this study was to determine the effect of four variables on electric air oven results as follows: (1) leaving dishes loosely covered; (2) size of samples; (3) increasing temperature 5°C.; and (4) weighing by difference. The directions sent to collaborators follow:

All determinations to be made in duplicate and duplicates reported. The work outlined is to secure information on three points: (1) effect of partially covering sample while drying; (2) effect of size of sample; and (3) weighing from closed container.

Method I. Place 2 grams of flour in a tared metal dish about 40 mm. in diameter and 25 mm. high and provided with a tight fitting cover. Dry to constant weight in an electric air oven at a temperature of 105°C. Bulb of thermometer to be on same level as samples. Covers of dishes to be entirely removed while drying, and to be replaced when samples are placed in desiccator for cooling.

Cool the dish in a desiccator and weigh as soon as the dish and contents reach the temperature of the air in the laboratory.

Method II. Proceed as in Method I, using sample of same weight, but instead of removing covers, dry with covers loosely placed on the dishes. Dishes to be tightly covered when placed in desiccator for cooling.

Method III. Proceed as in Method I, but use 5-gram sample of flour. Use dish of same size, covers of dishes to be entirely removed during drying.

Method IV. Proceed as in Method I, but dry to constant weight at a temperature of 110°C.

Note: For Methods I to IV it is presumed that samples are weighed as rapidly as possible either directly into tared dishes or in tared scoop and transferred to dishes.

Method V. Place about 10 grams of flour sample in weighing bottle and weigh. Weigh by difference into tared metal dishes (same size as preceding methods) samples of approximately 2-gram size. Dry as in Method I, with covers entirely removed during drying.

The following directions apply to all four methods:

(1) After placing flour sample in dish, tap dish lightly with pencil or spatula in order to distribute flour evenly over bottom surface of dish.

(2) Initial drying in all cases to be five hours.

(3) In reporting results, report per cent loss after five hours drying, and total per cent loss when constant weight is reached.

(4) State whether $CaCl_2$ or H_2SO_4 was used in desiccator.

Two samples of flour were sent to collaborators for this study. Sample 4 was a hard red spring patent and Sample 5 was a durum patent. The collaborating laboratories are designated by numbers, 7-15, and results are shown in Tables VII and VIII.

As in the case of results with vacuum methods, the average results indicate that five hours drying is not always sufficient to secure maximum results, but some results indicate that loss in weight from 5 hours drying is almost a maximum loss. Some collaborators report gain and variation in weight upon additional drying, but in all cases the maximum loss is reported.

Method II gave slightly higher average results for both samples; and shows only slightly higher variation. The variation between duplicates in Method II is less for Sample 4 and greater for Sample 5 than in Method I. Leaving dishes loosely covered, therefore, gives equally consistent results and possibly slightly higher results when drying in electric air oven.

The average results in Method III are only 0.01 per cent lower for both samples than in Method I. The results are similar in this case to those obtained with the vacuum method.

TABLE VII

RESULTS OF MOISTURE DETERMINATIONS WITH AIR OVEN (SAMPLE NO. 4)

	Oven type*	Desiccator reagent	Five-hour drying I	II	III	IV	V	Constant weight I	II	III	IV	V
			12.92	13.21	13.06	13.23	13.28	12.92	13.21	13.06	13.23	13.28
No. 7	F	$CaCl_2$	12.97	13.16	13.00	13.26	13.11	12.97	13.16	13.00	13.26	13.11
			12.95	13.19	13.03	13.25	13.20	12.95	13.19	13.03	13.25	13.20
			12.65	12.57	12.60	.....	12.29	13.00	13.00	12.90	.....	12.95
No. 8	C. S. Co.	H_2SO_4	12.60	12.57	12.59	.....	12.30	13.00	13.00	13.00	.....	12.90
			12.63	12.57	12.60	.....	12.30	13.00	13.00	12.95	.....	12.93
			12.89	13.03	12.96	13.15	13.06	13.07	13.24	13.06	13.19	13.16
No. 9	D. K.	$CaCl_2$	12.86	13.00	12.96	13.09	12.97	13.15	13.13	13.06	13.15	13.08
			12.88	13.02	12.96	13.12	13.02	13.11	13.19	13.06	13.17	13.12
			13.05	13.13	13.11	13.24	.....	13.02	13.14	13.04	13.22	13.22
No. 10	F	H_2SO_4	13.01	13.09	13.10	13.20	.....	12.97	13.11	13.06	13.16	13.16
			13.03	13.11	13.11	13.22	.....	13.00	13.13	13.05	13.19	13.19
			13.20	13.20	13.30	13.20†	13.20	13.20	13.20	13.30	13.20	13.20
No. 11	F	$CaCl_2$	13.20	13.20	13.30	13.20†	13.05	13.20	13.20	13.30	13.20	13.05
			13.20	13.20	13.30	13.20†	13.13	13.20	13.20	13.30	13.20	13.13
			12.76	12.76	12.58	12.88	12.72	12.78	12.80	12.56	12.88	12.72
No. 12	D	$CaCl_2$	12.76	12.62	12.48	12.87	12.71	12.77	12.62	12.54	12.87	12.71
			12.76	12.69	12.51	12.88	12.72	12.78	12.71	12.55	12.88	12.72
			12.82	12.96	12.89	13.14	12.69	13.04	12.99	12.90	13.19	12.95
No. 13	F	H_2SO_4	12.87	12.88	12.90	13.16	12.71	12.96	13.01	12.91	13.29	13.03
			12.85	12.92	12.90	13.15	12.70	13.00	13.00	12.91	13.24	12.99
			12.67	12.67	12.98	13.03	12.67	12.90	13.00	13.01	13.03	12.92
No. 14	D. K.		12.65	12.75	12.90	13.00	12.62	12.90	13.00	12.95	13.00	12.95
			12.66	12.71	12.94	13.02	12.65	12.90	13.00	12.98	13.02	12.94
			13.00	13.05	13.24	.....	.....	.....	.....	.....	.....	.....
No. 15	T	$CaCl_2$	13.02	13.10	13.15	.....	.....	.....	.....	.....	.....	.....
			13.01	13.08	13.20	.....	.....	.....	.....	.....	.....	.....
Average of averages			12.89	12.94	12.95	13.12	12.82	12.99	13.05	12.98	13.14	13.03
Maximum average			13.20	13.20	13.30	13.25	13.20	13.20	13.20	13.30	13.25	13.20
Minimum average			12.63	12.57	12.51	12.88	12.30	12.78	12.71	12.55	12.88	12.72
Maximum variation			0.57	0.63	0.79	0.37	0.90	0.42	0.49	0.75	0.37	0.48
Average variation between duplicates			0.03	0.05	0.03	0.03	0.07	0.03	0.05	0.03	0.04	0.08
Maximum variation between duplicates			0.05	0.14	0.09	0.06	0.17	0.08	0.18	0.10	0.10	0.17

*F=Freas oven, D. K.=DeKotinsky, D=Despatch, C. S. Co.=Central Scientific Co., T=Thelco.

†Two hours drying.

TABLE VIII

RESULTS OF MOISTURE DETERMINATIONS WITH AIR OVEN (SAMPLE No. 5)

	Oven type*	Desiccator reagent	Five-hour heating I	II	III	IV	V	Constant weight I	II	III	IV	V
			11.76	11.68	11.71	11.97	11.78	11.76	11.68	11.71	11.97	11.78
No. 7	F	$CaCl_2$	11.78	11.84	11.75	11.98	11.88	11.78	11.84	11.75	11.98	11.88
			11.77	11.76	11.73	11.98	11.83	11.77	11.76	11.73	11.98	11.83
			11.41	11.41	11.50	.....	11.28	11.75	11.78	11.89	.....	11.79
No. 8	C. S. Co.	H_2SO_4	11.42	11.41	11.49	.....	11.30	11.78	11.78	11.88	.....	11.80
			11.42	11.41	11.50	.....	11.29	11.77	11.78	11.89	.....	11.80
			11.80	11.85	11.75	11.94	12.06	12.04	12.22	11.87	12.02	12.20
No. 9	D. K.	$CaCl_2$	11.84	11.90	11.84	11.96	11.89	12.08	12.07	11.98	12.07	12.05
			11.82	11.88	11.80	11.95	11.98	12.06	12.15	11.93	12.05	12.13
			11.82	11.71	11.76	11.97	11.80	11.81	11.72	11.82	11.97	11.80
No. 10	F	H_2SO_4	11.80	11.73	11.76	11.90	11.81	11.79	11.78	11.77	11.90	11.81
			11.81	11.72	11.76	11.94	11.81	11.80	11.75	11.80	11.94	11.81
			12.00	11.75	12.00	12.00†	11.75	12.00	11.75	12.00	12.00	11.90
No. 11	F	$CaCl_2$	11.85	11.75	12.00	12.00†	11.75	11.85	11.75	12.00	12.00	12.00
			11.93	11.75	12.00	12.00†	11.75	11.93	11.75	12.00	12.00	11.95
			11.69	11.65	11.60	11.66	11.65	11.72	11.63	11.61	11.67	11.65
No. 12	D	$CaCl_2$	11.67	11.63	11.55	11.68	11.55	11.67	11.63	11.61	11.67	11.65
			11.68	11.64	11.58	11.67	11.60	11.70	11.63	11.61	11.67	11.65
			12.08	11.92	11.86	12.10	11.69	12.14	11.92	11.86	12.28	11.69
No. 13	F	H_2SO_4	11.87	12.07	11.77	11.98	11.72	11.98	12.07	11.78	12.18	11.72
			11.98	12.00	11.82	12.04	11.71	12.06	12.00	11.82	12.23	11.71
			11.30	11.50	11.48	11.92	11.42	11.57	11.75	11.63	11.92	11.75
No. 14	D. K.		11.32	11.50	11.46	11.87	11.47	11.54	11.77	11.69	11.87	11.82
			11.31	11.50	11.47	11.90	11.45	11.56	11.76	11.66	11.90	11.79
			11.35	11.45	11.59	.....	.....	.....	.....	.....	.....	.....
No. 15	T	$CaCl_2$	11.45	11.57	11.65	.....	.....	.....	.....	.....	.....	.....
			11.40	11.51	11.62	.....	.....	.....	.....	.....	.....	.....
Average of averages			11.68	11.69	11.70	11.93	11.68	11.83	11.82	11.81	11.97	11.83
Maximum average			11.98	12.00	12.00	12.04	11.98	12.06	12.15	12.00	12.23	12.13
Minimum average			11.31	11.41	11.47	11.67	11.29	11.56	11.63	11.61	11.67	11.65
Maximum variation			0.67	0.59	0.53	0.37	0.69	0.50	0.52	0.39	0.56	0.48
Average variation between duplicates			0.07	0.06	0.04	0.04	0.06	0.06	0.07	0.04	0.04	0.06
Maximum variation between duplicates			0.21	0.16	0.09	0.12	0.17	0.16	0.16	0.11	0.10	0.15

*F, D. K., D, C. S. Co., and T, see Table VI.
†Two hours drying.

The results obtained by drying at 110°C. (Method IV) average significantly higher than those of Method I. All but one collaborator obtained high results with Method IV for Sample 4, and all except two obtained high results with Sample 5. Increasing the temperature, however, does not uniformly give higher results. Method II gives the same average result for Sample 5 and only slightly higher result for Sample 4. The difference due to manner of weighing out samples is not so marked as in the case of vacuum methods. For Sample 4 only four of eight collaborators obtained higher results with Method V, but for Sample 5, six collaborators obtained higher results with Method V. The difference in favor of Method V, however, is very small.

Summarizing. Method II gives practically the same results as Method I. While Method III gives very slightly lower results than Method I, the difference is not significant. Drying at 110°C. gives higher average results than drying at 105°C. but some collaborators report lower results for Method IV. Method V (weighing by difference) shows less advantage than in vacuum drying. The results of studies with electric ovens also indicate that variation in results may be due to type of oven used.

Discussion.—A comparison of the vacuum oven, electric air oven, and water oven shows that there is a significant difference in results obtained with the three types of equipment. Prolonged heating in electric air oven does not give results equivalent to vacuum methods. It is possible that water exists in flour in at least three forms: (1) free water, (2) water of crystallization, and (3) water in physico-chemical combination with proteins. The amount of mineral salts present in flour is insignificant and the water of crystalization is probably insignificant. While moisture methods are supposed to remove only free water, it is obvious that no method yet devised is able to distinguish between the different forms of water. The water in loose combination with proteins is very probably affected by such factors as temperature, pressure, relative humidity, and possible other factors, as is suggested by difference in results obtained with electric ovens and water ovens. Gains in weight upon additional heating in air ovens indicate that certain constituents of the flour combine with oxygen of the air. In order to obtain uniform results, a moisture method must obviously control in some detail the conditions under which material is dried.

The studies on methods indicate that (1) loosely covered dishes give practically the same results as uncovered ones, but with the advantage of somewhat less variation for uncovered dishes in vacuum

drying; (2) 5-gram samples gave practically the same results as 2-gram samples; (3) weighing samples from weighing bottles gave slightly higher results, and this procedure may be advisable if operator can not weigh rapidly. The results also show that a long period of drying is essential for uniform results (five hours or more). No significant difference due to desiccating reagents used in desiccators was found.

The attention of the writer has been called to some minor details of moisture results which will be mentioned here.

Calculation. Some chemists report moisture to the fourth decimal place. The second decimal place is certainly the limit of accuracy.

Constant weight. A definition of constant weight would be advisable since there appears to be difference of opinion as to what this term denotes.

Among other factors which may affect moisture content and which in the writer's opinion should be studied are:

(1) size of desiccator used,
(2) number of dishes placed in desiccator,
(3) length of time cooled,
(4) how long a reheating is necessary to insure constant weight.

MINUTES OF TENTH ANNUAL CONVENTION OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

R. K. Durham, Secretary-Treasurer

Curtis Hotel, Minneapolis, Minn.
June 9-13, 1924

Monday, June 9, 1924

Meeting called to order at 11:00 a. m. at Curtis Hotel by President M. J. Blish.

Opening address by president.

Reading of communications.

Appointment of committees.

Nominating committee: H. F. Vaupel, chairman; Rowland J. Clark, L. H. Bailey.

Auditing committee: M. R. Warren, chairman; Charles G. Ferrari, J. C. Wood.

Resolutions committee: H. L. Lentz, chairman; F. S. Dunlap, D. A. Coleman.

T. A. Towner makes motion that no group picture be taken. Seconded; carried.

Meeting adjourned by motion at 11:45 a. m.

Tuesday, June 10, 1924

Meeting called to order at Curtis Hotel at 9:00 a. m. by President Blish.

Paper—"A Study of Gluten Washing," by D. B. Dill and C. L. Alsberg, Food Research Institute, Stanford University, Calif. In the absence of both authors paper was read by C. H. Bailey.

Paper—"Quality of Gluten," by C. B. Kress, Sperry Flour Co., Vallejo, Calif. Mr. Kress not present, paper read by L. A. Fitz.

Paper—"Effect of Storage on Baking Quality of Common and Durum Wheats," by C. E. Mangels, North Dakota Agricultural College, Fargo, No. Dak.

Paper—"A Few Essential Points on Experimental Milling," by Paul Pandermaly, Southwestern Milling Company, Kansas City, Mo.

Paper—"Factors that Affect the Quantity and Quality of Protein in Wheat," by C. O. Swanson, Kansas State Agricultural College, Manhattan, Kan.

Meeting adjourned by motion at 12:00 noon.

Wednesday, June 11, 1924

Meeting called to order at 9:00 a. m. by president, at Dunwoody Institute.

Address of welcome by Mr. Craigo, assistant director of Dunwoody Institute.

L. H. Bailey moved that convention convene at 3:00 p. m. for business meeting. Seconded.

Amendment moved that time be set for 4:30 instead of 3:00 p. m. Seconded, lost.

C. E. Mangels moved amendment that session open at 8:00 a. m. Thursday. Seconded, carried.

Original motion as amended carried.

Paper—"A Method of Counting Yeast Cells in Dough," by H. E. Turley, American Institute of Baking, Chicago, Ill.

Paper—"The Cake Flour Laboratory," by P. M. Patterson, Igleheart Brothers, Evansville, Ind.

Paper—"Bread Troubles in the Light of Hydrogen-ion Concentration," by Rowland J. Clark, Goerz Flour Mills Co., Newton, Kan.

Paper—"Formula and Method of Procedure for Experimental Baking Tests," by L. A. Fitz, Fleischmann Laboratories, New York, N. Y.

Paper—"Effect of Water Containing Free Chlorine in Bread Making," by C. B. Morison, American Institute of Baking, Chicago, Ill.

Moved by C. B. Morison that president appoint a committee to investigate and report on standard laboratory baking formula, method of procedure, and system of scoring loaf, and that allied agencies be utilized in securing constructive suggestions. Seconded and carried.

Recess for lunch.

Meeting called to order at 2:00 p. m.

Paper—"Carbon Dioxide Diffusion Ratio of Wheat Flour Doughs as a Measure of Fermentation Period and Flour Strength," by Arnold Johnson, Minnesota Agricultural Experiment Station.

Meeting adjourned by motion at 3:00 p. m.

Thursday, June 12, 1924

Closed Session

Meeting called to order at 8:15 a. m. by president, at Curtis Hotel.

Moved by L. A. Fitz that convention sustain President Blish's method of appointing nominating committee and approve committee as appointed. Seconded and carried. C. H. Bailey moved that minutes of the 1923 convention as published in the Journal of October, 1923, be approved. Seconded and carried.

Report of secretary-treasurer. (See attached report.)

A. W. Alcock moved adoption of secretary-treasurer's report. Seconded and carried.

Report of vice-president and chairman of the executive committee (no written report). Moved and seconded that report be accepted. Carried.

Report of auditing committee. (Treasurer's accounts found to be correct.) Report accepted by vote.

M. R. Warren moved vote of thanks to secretary-treasurer for excellent work during past year. Seconded, carried.

Report of committee on resolutions read and accepted. (See attached report.)

Report of nominating committee

Nominations for president

M. J. Blish, L. R. Olsen, C. E. Foster.

Nominations for vice-president

R. B. Potts, M. A. Grey, W. L. Rainey.

Nominations for secretary-treasurer

R. K. Durham, A. A. Heon, A. R. Sasse.

Editor-in-chief

C. H. Bailey, H. E. Weaver, M. R. Warren.

Managing editor

C. G. Ferrari, G. L. Alexander, L. E. Leatherock.

Moved that report be accepted and that convention proceed with election of officers. Seconded, carried.

Moved and seconded that election be by ballot. Carried.

Moved and seconded that chair appoint two tellers to count the ballots, carried. Chair appointed L. A. Fitz and L. H. Bailey.

Following officers elected:

President—M. J. Blish.
Vice-president—L. R. Olsen.
Secretary-treasurer—R. K. Durham.
Editor-in-chief—C. H. Bailey.
Managing editor—Charles G. Ferrari.

Appointment of committees

Committee on Allied Associations: H. E. Weaver, L. R. Olsen.

Coöperative Methods Committee: H. E. Weaver, L. R. Olsen.

Committee on Standardization of Laboratory Baking: L. A. Fitz, chairman. (Other members to be appointed later.)

Executive Committee: L. R. Olsen, D. A. Coleman, A. A. Heon, Robert W. Stark.

Report of Methods Committee. W. R. Mitchell moved report be accepted and that committee continue for next year work on methods as reported. Seconded and carried.

President appointed following as personnel of methods committee:

C. E. Mangels, chairman; J. C. Wood, C. H. Bailey, C. B. Kress, M. R. Warren, G. A. Shuey.

C. B. Morison, chairman of committee to draft preamble for constitution, made report. Proposed modification of Article II was read. (See attached report.) Moved and seconded that proposed amendment be adopted, carried.

C. B. Morison moved that further addition to incomplete constitution be made as follows: Article I. The name of this Association shall be THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Also that other parts of the constitution be arranged as Article II, III, IV, etc. Seconded and carried.

R. B. Potts proposed Amendments I and II to constitution as follows:

Amendment I

Art. V., Sec. 2 be amended as follows: The annual dues of this Association shall be five dollars per year, payable to the Secretary-Treasurer, of which three dollars shall constitute a subscription to the Journal of the Association, CEREAL CHEMISTRY, and shall be set aside as such. Said dues shall be payable strictly in advance and if not paid by the time of the March issue of the Journal said delinquent member shall be dropped from membership.

Amendment II

Art. IV., Sec. 2e be amended as follows: All applications for membership in this Association, where the qualifications of said applicant fully meet the requirements as set forth in the Constitution, shall be approved by the Secretary-Treasurer of this Association. Only applications in which qualifications are doubtful shall be submitted to the Executive Committee.

Adoption of proposed amendments moved and seconded. Carried.

C. E. Mangels moved that president appoint a committee to investigate and make suggestions on place of meeting, also that committee be appointed to arrange program for next convention and that president and secretary be members, ex-officio, of this committee. Seconded.

Moved to amend motion that committee be empowered to select and decide upon a place of meeting. Seconded. Lost.

Original motion passed.

President appointed program committee as follows: S. J. Lawellin, C. O. Swanson, R. J. Clark.

President appointed committee on meeting place as follows: R. S. Herman, F. S. Dunlap, A. A. Heon.

L. A. Fitz moved secretary be instructed to send greetings to Mr. Ismert. Seconded, carried.

Meeting adjourned by motion at 12:30 p. m.

Friday, June 13, 1924

Meeting called to order at 9:00 a. m. by president, at University Farm.

Paper—"Gluten Quality," by R. A. Gortner, University of Minnesota.

Paper—"Viscosity Measurements in Wheat Breeding Practice," by C. H. Bailey, University of Minnesota.

Paper—"A Practical Application of the Viscosimeter to the Mill," by Ralph Morgan, Newton Milling and Elevator Co., Newton, Kan.

Paper—"The Gluten Quality of the Mill Streams as Measured by the Viscosity Method," by Julius Hendel, Cargill Elevator Co., Minneapolis, Minn.

Paper—"The Control of Diastatic Activity of Flour," by R. C. Sherwood, University of Minnesota.

Convention adjourned by motion at 12:45 p. m.

Report of Secretary-Treasurer

June 7, 1924

This has been a very profitable year for the association. The membership has increased from 169 to 237. Paid subscriptions to the Journal in 1923 were about 25, for 1924 there are 107. The treasurer's report at the end of last year showed 53 members in arrears amounting to $345. Now we have 53 members in arrears and the amount is $308.73; 78 per cent of members are paid to January, 1925. Fifteen of those charged with failure to pay dues are paid to June 1, 1924, but according to the constitution dues must be paid in advance for the calendar year hence these members must be classed as delinquent. On June 4, 1923, the membership totaled 169, divided as follows: Active 126, associate 12, sustaining 29, and honorary 2. Fifty-one members were added by the amalgamation with A. S. M. B. T. Forty-eight new members have been approved during the year, 32 have been dropped on account of failure to advise of change of address or failure to pay dues, or have resigned.

We now have 237 members divided as follows: Active 191, associate 12, sustaining 32, and honorary 2.

DETAILED MEMBERSHIP STATEMENT—JUNE 7, 1924

	Active	Associate	Sustaining	Honorary	Total
Membership June 1, 1923	126	12	29	2	169
New members added	38	2	8	0	48
Re-instated	1	0	0	0	1
Associate transferred to active	1	0	0	0	1
Added by A. S. M. B. T.	51	0	0	0	51
	217	14	37	2	270
Deductions					
Resigned and dropped	26	1	5	0	32
Associate transferred to active	0	1	0	0	1
	26	2	5	0	33
Membership June 7, 1924	191	12	32	2	237

STATEMENT OF MEMBERS OWING BACK DUES

Number owing	$2.50	$5.00	$7.50	Over $7.50	Paid to Jan., 1925	Total
A. A. C. C.	15	13	10	6	148	192
A. S. M. B. T.	0	6	2	1	36	45
	15	19	12	7	184	237

STATUS OF A. S. M. B. T. MEMBERS ADDED

Resigned	6
Arrears from January, 1923	1
Arrears from June, 1923	2
Paid to January, 1924	5
Paid to January, 1925	37
	51

REPORT OF TREASURER OF A. A. C. C.

June 7, 1924

Receipts

A. A. C. C. Treasurer's cash balance June 1, 1923	$68.73	
A. S. M. B. T. Treasurer's balance June 4, 1923	445.12	
Stanford Food Research Committee	200.00	
Dr. C. H. Bailey, Treasurer Minnesota Baker's Service Board	66.74	
Sale of back Journals and methods of analysis	29.38	
Advertising in Journal	769.09	
Subscriptions to Journal	323.81	
Membership dues and annual dues	2,044.37	
Total receipts		$3,947.24

Expenditures

Officers' expense previous to June, 1923	$75.00	
Typewriter for Secretary	65.00	
One-half interest in addressograph machine	18.57	
Multigraph printing machine	45.00	
Secretarial supplies	83.64	
Expense of officers' meeting at Lincoln	96.40	
Editing, printing, mailing and other Journal expense (not including May, 1924, number)	2,027.37	
Badges for convention	37.50	
Mailing convention programs and literature	13.61	
Miscellaneous expenses	44.58	
Total expenditures		$2,506.67
Cash on hand June 7, 1924		1,440.57
		$3,947.24

Assets		
Cash on hand	$1,440.24	
Unpaid dues	308.73	
Unpaid advertising	170.30	
Unpaid subscriptions	17.50	
Total assets		$1,936.77
Liabilities		
Stanford Food Research	$200.00	
Total liabilities		200.00
Credit Balance		$1,736.77

R. K. Durham,
Secretary-Treasurer A. A. C. C.

REPORT ON PREAMBLE TO REVISED CONSTITUTION OF AMERICAN ASSOCIATION OF CEREAL CHEMISTS

By C. B. Morison

At the June, 1923, meeting of the association, the writer was requested by the president to present a preamble to the constitution of the association for consideration by the membership, which would more clearly define the purposes and objects of this association.

The writer has examined the constitution of the association as published in Vol. VIII, No. 3, page 155, July, 1923. The purpose of this association is stated there to be as follows:

"The purpose of this association is to reach by means of research and discussion, agreement in the methods of analysis necessary in the cereal laboratory. The object to be accomplished is the establishment of standard methods of procedure in the analysis of cereal products."

According to the statement of purpose the activities of this association are limited to a discussion of analytical methods, their study and adoption.

At the June, 1923, meeting it seemed to be the sense of the members that the purpose of the association should not be so restricted, and that the interest of the association in the promotion of scientific research and technical applications in the field of cereals should be included in a revision of the purposes of the association.

The writer therefore presents the following revision of Article II of the constitution.

Article II

Purposes of the Association

The purposes of this association are: (1) The encouragement and advancement of scientific and technical research in cereals and their products, particularly in milling and baking, but including also other industries in which cereals and their products are utilized, (2) the study of analytical methods used in cereal chemistry and the development and adoption of uniform (or standard) methods of examination and analysis, (3) the promotion of the spirit of scientific co-operation among all workers in the field of cereal knowledge, (4) the maintenance of high professional standards in the association as conditions of membership, and (5) to encourage a more general recognition of the chemist and biologist as essential factors in the development of the cereal industries. In accordance with these purposes this association shall conduct a journal in which contributions to the scientific knowledge of cereals, their products and technical application shall be published for the encouragement and advancement of the science. It shall hold annual or other meetings for the discussion of cereal knowledge and the promotion of research and technical co-operation among its members.

RESOLUTIONS

WHEREAS, We believe that this Tenth Annual Convention of the American Association of Cereal Chemists, convening June 9-14, 1924, at the Curtis Hotel, Minneapolis, Minn., has been one of the best and most successful conventions we have ever held, and

WHEREAS, The arrangement of the varied and timely topics that have been presented for discussion has been due largely to the initiation and foresight of our worthy president, and

WHEREAS, Much of the success of the convention has also been due to the thoughtful planning of the local committee on arrangements, the co-operation they have received from the various educational and industrial institutions and from individuals representing the allied interests, therefore

BE IT RESOLVED, That we congratulate our president, M. J. Blish, and our local committee on arrangements, Messrs. Olsen, Bailey, and Ferrari, on the success achieved in planning the program and entertainment; and that we express our hearty appreciation and tender sincere thanks to the Minnesota College of Agriculture and Dunwoody Institute for the privilege of holding part of our sessions at these institutions and for the opportunities afforded to visit their various departments, including the state mill. To the Purity Baking Co., the

Occident Baking Co., the Washburn-Crosby Co., and the Pillsbury Flour Mills Co. for the courtesies extended in our visits to their plants. To the persons representing the allied interests which kindly furnished transportation from the hotel to the various institutions and industries.

BE IT FURTHER RESOLVED, That we express to the Messrs. Bailey and Ferrari our hearty appreciation of the excellent manner in which they have overcome many difficulties and arranged for the publication of our journal, Cereal Chemistry, and we congratulate them upon its excellence, and that we also recognize and appreciate the untiring, faithful service of our secretary-treasurer, R. K. Durham, and

BE IT ALSO RESOLVED, That our secretary be instructed to convey to the management of the Curtis Hotel our appreciation and sincere thanks for the excellent accommodations, service, and co-operation received and the splendid spirit in which this has been rendered.

Committee on Resolutions,

H. L. LENTZ, *Chairman*
D. A. COLEMAN
L. A. FITZ

Convention Registration

A. W. Alcock, Western Canada Flour Mill, Winnipeg, Can.
C. A. Armstrong, Igleheart Milling Co., Evansville, Ind.
G. L. Alexander, Geo. P. Plant Milling Co., St. Louis, Mo.
C. H. Bailey, University Farm, St. Paul, Minn.
L. H. Bailey, Bureau of Chemistry, U. S. Dept. of Agr., Washington, D. C.
W. L. Bergman, Industrial Appliance Co., Chicago, Ill.
M. J. Blish, Agricultural Experiment Station, Lincoln, Neb.
M. F. Borman, Ridgeway's Tea, Minneapolis, Minn.
G. W. Bouskill, Dunwoody Institute, Minneapolis, Minn.
G. S. Bratton, Liberty Yeast Corp., Pekin, Ill.
C. H. Briggs, Howard Laboratory, Minneapolis, Minn.
L. G. Brown, Dunwoody Institute, Minneapolis, Minn.
Walter B. Brown, Victor Chemical Co., Chicago, Ill.
Frank Carr, The Southwestern Laboratories, Kansas City, Mo.
Lee E. Clark, Kansas City Laboratory Supply Co., Kansas City, Mo.
Rowland J. Clark, Goerz Flour Mills Co., Newton, Kan.
D. A. Coleman, Bureau of Agricultural Economics, Washington, D. C.
F. A. Collatz, American Diamalt Co., Cincinnati, Ohio.
H. E. Curtis, Midland Flour Mills, Kansas City, Mo.
S. E. Danielson, Quaker Oats Co., Akron, Ohio.
R. O. Davis, Dunwoody Institute, Minneapolis, Minn.
L. H. Dawson, W. J. Jennison Co., Appleton, Minn.
F. L. Dunlap, Industrial Appliance Co., Chicago, Ill.
R. K. Durham, Rodney Milling Co., Kansas City, Mo.
S. J. Durigan, Dunwoody Institute, Minneapolis, Minn.
Frank W. Emmons, Washburn-Crosby Co., Minneapolis, Minn.

W. G. Epstein, Eckhardt Milling Co., Chicago, Ill.
Newton C. Evans, National Miller, Chicago, Ill.
Mrs. Isabel J. Everts, Purity Baking Co., St. Paul, Minn.
P. C. T. Ewert, Dunwoody Institute, Minneapolis, Minn.
Chas. G. Ferrari, Dunwoody Institute, Minneapolis, Minn.
W. M. Finch, Wallace & Tiernan Co., Minneapolis, Minn.
V. E. Fisher, Standard Tilton Milling Co., Alton, Ill.
L. A. Fitz, Fleischmann Co., New York City
T. G. Fletcher, Wichita Mill & Elevator Co., Wichita Falls, Tex.
F. F. Flinchbaugh, University of Minnesota, Minneapolis, Minn.
J. A. Flohil, Pillsbury Flour Mills, Minneapolis, Minn.
E. N. Frank, Washburn-Crosby Co., Minneapolis, Minn.
R. A. Gortner, University Farm, St. Paul, Minn.
M. A. Gray, Pillsbury Flour Mills, St. Paul, Minn.
W. L. Grapp, Despatch Manufacturing Co., Minneapolis, Minn.
Walter Hall, Clay Center Testing Laboratories, Clay Center, Kan.
C. E. Foster, Hecker-Jones-Jewell, New York City
Julius Hendel, Cargill Elevator Co., Minneapolis, Minn.
R. S. Herman, Ismert-Hincke Milling Co., Kansas City, Mo.
A. A. Heon, Bernard-Stern Milling Co., Milwaukee, Wis.
Miss Rose Holub, International Milling Co., Minneapolis, Minn.
R. Hoppin, Allis-Chalmers Manufacturing Co., Minneapolis, Minn.
N. Inbody, Dunwoody Institute, Minneapolis, Minn.
Chas. W. Ingman, W. J. Jennison Co., Minneapolis, Minn.
Arnold H. Johnson, University of Minnesota, Minneapolis, Minn.
Rolfe L. Frye, Kansas Flour Mills, Kansas City, Mo.
S. J. Lawellin, Wallace & Tiernan Co., New Ulm, Minn.
L. E. Leatherock, Kansas Milling Co., Wichita, Kan.
H. L. Lentz, Robinson Milling Co., Salina, Kan.
Edward L. N. McIlhenny, University Farm, St. Paul, Minn.
C. E. Mangels, North Dakota Agricultural College, Agricultural College, N. D.
K. H. Marts, Dunwoody Institute, Minneapolis, Minn.
R. S. Mather, Leavenworth Mill & Elevator Co., Leavenworth, Kan.
Miss Elizabeth McKim, University Farm, St. Paul, Minn.
G. Mehlin, W. J. Jennison Co., Minneapolis, Minn.
Wallace Mitchell, American Bakery Materials Co., Menominee, Wis.
P. E. Minton, Acme-Evans Co., Indianapolis, Ind.
G. Moen, Washburn-Crosby Co., Minneapolis, Minn.
J. H. Monson, Robin Hood Mills, Ltd., Moose Jaw, Sask., Can.
Ralph P. Morgan, Newton Mill & Elevator Co., Newton, Kan.
C. B. Morison, American Institute of Baking, Chicago, Ill.
H. G. Nelson, International Milling Co., Minneapolis, Minn.
Chas. T. Newell, Oklahoma Mill Co., Kingfisher, Okla.
W. I. Nightingale, Washburn-Crosby Co., Minneapolis, Minn.
Aksel G. Olsen, Postum Cereal Co., Battle Creek, Mich.
Leslie R. Olsen, International Milling Co., Minneapolis, Minn.
Clarence O. Oppen, Lawrenceburg Roller Mills, Lawrenceburg, Ind.
M. H. Parlin, Lysle Milling Co., Leavenworth, Kan.
F. D. Patterson, Texas Star Flour Mills, Galveston, Tex.
P. Pandermaly, Southwestern Milling Co., Kansas City, Mo.
R. B. Potts, Wichita Flour Mills Co., Wichita, Kan.

H. H. Prager, Dunwoody Institute, Minneapolis, Minn.
S. L. Redman, Central Scientific Co., Chicago, Ill.
W. A. Richards, Washburn-Crosby Co., Minneapolis, Minn.
Chas. C. Roberts, Arthur H. Thomas Co., Philadelphia, Pa.
T. C. Roberts, Washburn-Crosby Co., Minneapolis, Minn.
Thos. W. Sanford, Eagle Roller Mills Co., New Ulm, Minn.
L. A. Scanland, Southwestern Laboratories, Kansas City, Mo.
G. H. Schmidt, City Baking Co., Baltimore, Md.
R. C. Sherwood, University Farm, St. Paul, Minn.
G. A. Shuey, Pennsylvania State College, State College, Pa.
Oscar Skovholt, State Mill & Elevator Co., Grand Forks, N. D.
G. S. Slenade, St. Louis, Mo.
C. G. Solsten, Wilhoit Laboratory, Minneapolis, Minn.
K. W. Stark, University of Illinois, Champaign, Ill.
Chas. T. Stork, Noury & Van der Lande, Buffalo, N. Y.
Miss Betty Sullivan, Russell-Miller Milling Co., Minneapolis, Minn.
C. O. Swanson, Kansas State Agricultural College, Manhattan, Kan.
H. R. Swanson, Robin Hood Mills, Calgary, Alberta, Can.
Thos. J. Totushika, Cargill Elevator Co., Minneapolis, Minn.
E. F. Tibbling, Washburn-Crosby Co., Kansas City, Mo.
A. A. Towner, Red Star Milling Co., Wichita, Kan.
W. A. Tinkham, Washburn-Crosby Co., Minneapolis, Minn.
H. E. Turley, American Institute of Baking, Chicago, Ill.
H. F. Vaupel, El Reno Mill & Elevator Co., El Reno, Okla.
M. R. Warren, Quaker Oats Co., Cedar Rapids, Iowa
G. F. Weiss, Northwestern Cereal Laboratory, Minneapolis, Minn.
L. D. Whitting, Ballard & Ballard Co., Louisville, Ky.
J. C. Wood, Scott County Milling Co., Sikeston, Mo.